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LAURENTIAN GREAT LAKES BASIN CLIMATE CHANGE ADAPTATION

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ATMOSPHERIC ADMINISTRATION

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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

Report prepared for NOAA Great Lakes programs:
Great Lakes Regional Collaboration Team
Great Lakes Environmental Research Laboratory
Great Lakes Sea Grant
Sustainable Coastal Community Development
Extension Agent Network
Ohio Coastal Training Program at Old Woman Creek National Estuarine Research Reserve
Ohio State Nature Preserve (ODNR/Division of Wildlife)

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1. EXECUTIVE SUMMARY

The NOAA Great Lakes Regional Collaboration Team, Great Lakes Sea Grant Network, and Old Woman Creek National Estuarine Research Reserve are working with the Great Lakes & Saint Lawrence Cities Initiative to develop specialized training to build the capacity of Great Lakes coastal communities to adapt to the impacts of climate change. 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. To ensure that training meets priority needs and provides accessible and applicable tools and resources, these organizations are collaborating to conduct a needs assessment: a comprehensive front-end evaluation of the climate change adaptation training and information needs of Great Lakes coastal communities. The goal of this needs assessment is 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 is being conducted in two phases with funding from the NOAA Sea Grant Climate Engagement Project and the Great Lakes Restoration Initiative. This report contains the results of Phase I, a synthesis of existing knowledge on training and information needs and preliminary data collection, funded by the NOAA Sea Grant Climate Engagement Project. Phase II will include comprehensive data collection and be funded by the Great Lakes Restoration Initiative and coordinated by Old Woman Creek National Estuarine Research Reserve. Phase II results and recommendations will be compiled as a companion document to this report. These organizations will utilize the results of both phases of this needs assessment to design climate change adaptation training for Great Lakes coastal community decision-makers and professionals. Study results and recommendations can also guide future investments in Great Lakes climate change adaptation training.

This issue areas reported here include background information, climate impacts, and relevant roles for stakeholder engagement. This is followed by categorizing needs in two sections: research, planning, and policy needs, and then education and training needs. This information is included in each chapter. Some chapters also include more precise information for specific issue areas that have been placed in the overarching chapter theme. However, these specific issue areas

are relevant to numerous issues in the complexity of climate change adaptation, and should be considered in the overall context of both mitigation and adaptation planning.

2. METHODS

The methodology outlined in the NOAA Coastal Services Center needs assessment training module[1] was utilized for this study. This methodology involves three project phases that consist of planning, data collection, and data analysis and reporting:

Planning
- Confirm the issues and audiences
- Establish a planning team
- Establish goals and objectives
- Characterize audience
- Conduct information and literature search

Data Collection
- Select data collection methods
- Determine sampling scheme
- Design and pilot the collection instrument
- Gather and report data

Data Analysis and Reporting
- Analyze data
- Manage data
- Synthesize data and create report

For emphasis, note that all steps listed under planning, which are steps one through five of the NOAA needs assessment process, completes phase I. Phase II, as indicated previously, will be published as a companion document to this report, and include all steps under data collection, analysis, and reporting (steps 6 through 12).

3. GOALS AND OBJECTIVES

The goal of this study is to collect sufficient information about the needs 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.

3.1 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

[1]NOAA needs assessment training module available at: www.csc.noaa.gov/needs/home.html

- 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. PHASE I: RESEARCH PLANNING

4.1 Issue Identification

The Laurentian Great Lakes basin consists of Lakes Michigan, Huron, and Superior, referred to as the upper Great Lakes, and Lakes Erie and Ontario, referred to as the lower Great Lakes. Four of these lakes are binationally governed between the US and Canadian governments. Only Lake Michigan is solely within US jurisdiction; however, Michigan and Huron are directly connected through the Straits of Mackinac, and share hydrologic fluctuation. There are 158 coastal US counties, 121 watersheds, and approximately 13 major urban areas in the Great Lakes basin[2].

Four different climate change scenarios are possible for the Great Lakes region: "warmer and dry," "hot and dry," "warmer and wet," and "hot and wet", which provide for a range of scenarios with precipitation and evaporation as the most significant factors effecting Great Lakes water levels[3]. Each scenario indicates 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[3]. The parameters of long term planning, then, are reasonably estimated with a decline in lake levels, yet still allowing for a possible yet unlikely water level increase in the lower Great Lakes. Furthermore, it is also predicted that extreme precipitation events will increase the need for resilience to higher storm water levels and flooding[4].

In Confronting Climate Change in the Great Lakes Region, it is anticipated that:
- "Winters are getting shorter.
- Annual average temperatures are growing warmer.
- Extreme heat events are occurring more frequently.
- The duration of lake ice cover is decreasing as air and water temperatures rise.
- Heavy precipitation events, both rain and snow, are becoming more common."[5]

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[2] NOAA's State of the Coast. The U.S. Population Living in Coastal Counties. http://stateofthecoast.noaa.gov/population/welcome.html

[3]Based on a presentation by Thomas E. Croley II. 2007. The Once Great Lakes? included in the summary report "Starting a public discussion: Climate Change in the Great Lakes Region." prepared by Stephen Wittman. 2008. Available at: http://www.glerl.noaa.gov/pubs/fulltext/2008/20080009.pdf

[4]Safford, T., Thompson, J., and P. Scholz. 2005. Storm Surge Tools and Information: A User Needs Assessment. NOAA Coastal Services Center: Charleston, SC.

[5]Confronting Climate Change in the Great Lakes Region Impacts on Our Communities and Ecosystems. 2005. Report of The Union of Concerned Scientists and The Ecological Society of America.

4.2 Initial GLSLCI[6] Community Input: Audience and Issues

As a first step in the needs assessment process, the team gathered the perspectives of three Great Lakes and Saint Lawrence Cities Initiative member communities regarding who they think would be most likely to have a role in coastal community adaptation planning, and what the communities' perspectives are regarding regional climate change impacts, vulnerability of local assets to these impacts, and the challenges they face in planning to adapt.

The three responding communities indicated that those involved in climate adaptation planning are likely to work at a variety of scales, from local to national, and across many sectors, from tribal, federal, or local government to the university, non-profit, and business sectors. Community input identified several additional professional and elected positions that have a role in adaptation planning after reviewing an initial list that had been generated by the project team.

A general description of the target audience are professional planners, stormwater managers, and natural resource managers working in Great Lakes coastal counties or watersheds.

More specific roles are:

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

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

Natural resource manager
- Parks and recreation directors
- City Forester
- Park managers

Policy-makers
- City Council members
- Township Trustees
- Mayors
- County Commissioners

[6]GLSLCI: Great Lakes St. Lawrence Cities Initiative

- State Representatives
- Representatives and Staff on State Legislature Natural Resource and Environment committees
- Staff on State Departments of Natural Resources and Departments of Environmental Quality Protection

Additions suggested by community reviewers include: coastal geomorphologists, parks & recreation professionals, city forester, directors of sustainability port directors, environmental protection/quality agencies, zoning director, energy procurement managers, housing and economic/business development staff, architects, human services, emergency preparedness, scientists, and environmental health professionals.

All three communities identified lake level change, coastal erosion, river flooding, changes in extreme weather events, water quality changes, and drought as potential climate change impacts. Two communities identified precipitation, spread of invasive species, and heat, and one community mentioned pressure on aquatic species and coastal flooding as potential climate change impacts.

All three communities identified drinking water, stormwater, wastewater, shoreline infrastructure, beaches and coastal ecosystems as being most vulnerable to climate change impacts[7].

4.3 GLSLCI Meeting Attendee Input[8]:

4.3.1 Awareness, Adaptation Planning Status, Resource, Tool, and Training Needs

A separate survey gathered anecdotal input from a small group of Great Lakes Saint Lawrence Cities Initiative 2010 conference attendees regarding climate change awareness, engagement in and strategies for adaptation planning, barriers and benefits related to adaptation planning, and resources, tools, and training needs. This input will inform the development of Great Lakes Sea Grant Network Climate Engagement training modules and the design of questioning routes for interviews and focus groups to be conducted in Phase II.

The nine GLSLCI 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).

[7] See Appendix I for summary of initial GLSLCI responses

[8] Great Lakes St. Lawrence Cities Initiative Annual Members meeting June 16-18, 2010: Milwaukee, Wisconsin

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).

4.4 Module Development and Review

An additional layer of module development was included for purposes of establishing clear boundaries between potential focus group participants and module reviewers recruited through similar professional networks. This was established by recruiting module reviewers through the Sea Grant network early in the process. An email invitation was composed and sent out through the Sea Grant network requesting recommendations for module reviewer participants. People were then contacted by email or telephone to confirm interest in participating. Those who have elected to participate expect to be notified of opportunities and material for review throughout the development process, with the student intern for the phase II needs assessment acting as liaison in communication. The proposed time commitment for module review is between two and four occasions from early summer to December 2010, with an estimate of one to two hours of actual module review. This feedback will then be made available to module teams, and included as an addendum to this needs synthesis report.

5. OVERVIEW: PRIORITY ADAPTATION NEEDS

Increased variability of extremes will be difficult to prepare for. As such, it is essential that any uncertainty in anticipated events be accounted for in types of structures and adaptation plans for communities. This is the basis of adaptive management. Water quality will depend on the integrity of water management systems; drinking, storm, and waste water each have

specific infrastructure that require a mix of adaptive management approaches. This issue area is highlighted throughout each chapter.

Also inherent in an adaptive management approach is the need for increased communication on multiple scales. Coordination and communication between all stakeholders is a key theme in all chapters. Data sharing from monitoring systems and data for 48 hour forecasting are tools for decision making that can be shared on a local and regional level. These data are useful for numerous socio-economic needs: real-time monitoring can equip researchers and modelers with the information needed to produce weather and water quality forecasts as a public health and safety service. Specific examples of this are weather and water quality monitoring for beach recreation, as well as weather monitoring and forecasting for recreation and commercial marine navigation. While these are short term benefits of comprehensive observation systems, the long term benefits of accumulating longitudinal data will assist in determining any long term trends in a changing climate, and can provide decision makers with the information they need to resolve large scale infrastructure, logistical, and operational issues, such as managing the shoreline infrastructure that supports the commercial movement of goods in the maritime community.

Throughout this report, information needs are highlighted in all issue areas, and the reader is urged to pay close attention to the inter-relationship of all issue areas of coordination through this lens of "data information integration and distribution" or DIID[9].

"The need for real time monitoring is also particular to a changing climate; reliance on past averages to as a primary planning reference is no longer sufficient. The National Federation for regional associations for coastal and ocean observing describe the need to support adaptive management through regular synthesis of coastal data. 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."[10]

In 2008, the NOAA Great Lakes Environmental Research Laboratory held a climate workshop that delved into the 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. A summary report from this workshop includes a similar yet more robust listing of issue areas, research and training needs as reported here, and should be referenced in its entirety[11], as well as the Climate-Related Needs Assessment Synthesis report in 2008 for the NOAA Coastal Services Center[12].

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[9]Desotelle Consulting, PLC; Community Growth Institute, and Beaster Consulting. July 2006. Great Lakes Needs Assessment: Issue Area: Data Information Integration and Distribution. Produced for the Great Lakes Commission and NOAA/Coastal Services Center. Available at: http://glc.org/regionalneeds/documents/FinalDIIDNeedsAssessmentJuly2006_000.pdf

[10]Safford, Thompson, and Scholz, 2005. Storm Surge Tools and Information: A User Needs Assessment." NOAA Coastal Services Center: Charleston, SC, p. 17.

[11]Michigan Climate Workshop Summary and Full Reports (147a and 147b) can be found at: http://www.glerl.noaa.gov/pubs/techrept.html. Full citations are in the references section of this report.

[12]Fauver, S. 2008. Climate-Related Needs Assessment Synthesis for Coastal Management. Synthesis Report for the National Oceanic and Atmospheric Administration Coastal Services Center: Charleston, SC. Available at: http://www.csc.noaa.gov/needsassesments/

Additionally, the National Research Council include in their report Informing Decisions in a Changing Climate an emphasis on how to assume strong leadership across the federal government, a need that is listed in this report primarily under ecosystem based and coastal management, but is applicable in many areas. The basis for the full list of recommendations that the National Research Council makes 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 **"Recommendation 1: Government agencies at all levels and other organizations, including in the scientific community, should organize their decision support efforts around six principles of effective decision support: (1) begin with users' needs; (2) give priority to process over products; (3) link information producers and users; (4) build connections across disciplines and organizations; (5) seek institutional stability; and (6) design processes for learning"** (National Research Council, 2009)[13].

Consider these decision support principles in the context of the thematic areas that are characterized in the following chapters: Infrastructure: ports, regional planning, and water; ecosystem based management, coastal planning and management, and hazard resilience/ disaster preparedness. Although there are more theme areas that could be included here, such as protection of source water for drinking, the elements of discussion that are presented here offer strong points of entry to address specific climate adaptation needs on multiple scales.

6. INFRASTRUCTURE: PORTS AND REGIONAL PLANNING

The marine and land transportation infrastructure in the Great Lakes basin is part of the basic foundation of the national economy. However, much of the shoreline transportation infrastructure (navigation channels, breakwalls, docks, piers, etc.) is in extreme need of improvement. The commercial value of the water transportation of goods is what can maintain a competitive economy since the cost of moving goods (heavy bulk commodities such as coal, grain, stone and iron ore) via water transport is considerably less than shipping overland. Emergent is the idea of "short sea shipping": to move goods short distances over water to lessen cost and emissions of shipping overland. As lake levels decrease, the need for dredging of channels will increase to maintain water shipping viability.

As the regional transportation infrastructure between land and maritime communities is a foundational component of the national economy, it is increasingly important to factor intermodal transportation hubs (regional planning) into short and long term decision-making processes, as well as to provide relevant information for decision support at all scales.

6.1 Climate Impacts

Decreasing lake levels and stronger storm events will increase the need for dredging and the disposal of this dredged material. Warmer seasons and shorter periods of ice cover may lengthen

[13]For a full list of recommendations for supporting climate related decision making, see the full report *Informing Decisions in a Changing Climate.* A full citation is in the references section of this report.

the shipping season. Extreme precipitation events will cause flooding in certain areas. This will impact navigation, operational strategies, and the logistics of routing. All of these physical changes will increase the need for real time observation, monitoring, 48-hour forecasting and data distribution. Many of these issues can be addressed through the framework of coastal and marine spatial planning identified in the final recommendations by the Inter-agency Ocean Policy Task Force, lead by the White House Council on Environmental Quality (IOPTF, 2010)[14].

6.2 Relevant Roles

Port authorities, regional and local planners, developers, sustainability directors, zoning director/ administrator, emergency management director, water and resource managers, engineers; Federal, State, and local policy-makers and transportation agencies and officials, shippers, environmental laboratories (governments, universities, and other research institutions), weather forecast modelers.

6.3 Adaptation Needs: Research, Planning, and Policy

- Port and harbor planning
- Include climate impact analysis in reporting requirements
- Coordinate timeframes for planning for city, state, federal levels of government
- Modify operational strategies to address climate impacts on:
- Seaway systems: locks, channels
- Vessel maintenance, routing, and operationsPort construction and maintenance
- Regional planning for port, railway, and highway infrastructure
- Prioritization of resource allocation for mitigation and adaptation actions
- Coordination of regional needs: large-scale calculations at federal and state levels
- Cost/benefit analyses of dredging and regional port utility
- Shoreline inventory
- Data distribution, downscaling regional information to local conditions for navigation
- Aquatic invasive species (AIS) and ballast water: operational and control planning
- Real time observation, monitoring, and data distribution
- 48-hour forecasting for marine navigation
- Erosion control methods
- Regional/local analysis and planning between land and marine communities
- Port and harbor management
- Port consolidation and land side transportation networks

6.4 Adaptation Needs: Education and Training

- Erosion control methods that link upstream causes to downstream impacts
- Knowledge transfer of commercial shipping industry in Great Lakes
- Creating relationships between policy-makers, industry, and social systems to optimize opportunities for knowledge transfer
- Relationship between land and marine communities

[14]White House Council on Environmental Quality. 2010. Final Recommendations of the Interagency Ocean Policy Task Force July 19, 2010. Available at http://www.whitehouse.gov/administration/eop/ceq/initiatives/oceans.

- Aquatic invasive species awareness: ballast water management
- Port and harbor management: commercial activity can complement or threaten
- Public access design
- Environmental restoration opportunities in estuaries
- Benefit/cost analysis of adaptation alternatives
- Benefit/cost analysis of mitigation alternatives
- Practical adaptations to maintain the cost effectiveness and competitive advantage of water transportation
- Funding strategies for value added construction efforts to extend facility life cycles

7. INFRASTRUCTURE: WATER

Water infrastructure in the Great Lakes basin is a priority issue area, as much of it is aging and in poor condition, increasing the risk of waterborne outbreaks of illness and disease (Patz et al, 2008). The US Corps of Civil Engineers have rated wastewater infrastructure with a D-, faring the worst over all other forms of infrastructure (ASCE, 2005). As increased precipitation events will inundate impervious surfaces and result in extreme amounts of overland runoff, it will also stress capacity of combined sewer systems. This will potentially and likely decrease water quality. The US EPA 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 (US EPA, 2008). The 14th Biennial Report on Great Lakes Water Quality by the International Joint Commission recommends that both US and Canadian "economic-stimulus measures now being developed should address wastewater system needs in the Great Lakes basin" (IJC, 2009).

7.1 Climate Impacts

Climate change in the Great Lakes area is expected to bring more intense episodes of precipitation (rain, snow, sleet), and thus frequent episodes of flooding are also predicted. However, current infrastructure for stormwater may not be sufficient to handle the intense episodes of precipitation, which has implications for both flooding issues and water quality. Even areas that traditionally do not experience flooding may experience more flood events.

Seasonal distribution is likely to vary greatly, increasing in winter and decreasing in summer. Overall, the region may grow drier because any increases in rain or snow are unlikely to compensate for the drying effects of increased evaporation and transpiration in a warmer climate. This drying will affect surface and groundwater levels, and soil moisture is projected to decrease by 30 percent in summer. Dryer soil will increase the amount of surface water runoff, and combined with increased frequency of 24-hour and multiple day downpours, flooding events will also increase.

7.2 Relevant Roles

Developers, County Emergency Director, City Manager, Emergency Management, Emergency Response (e.g., fire rescue, police), Public Works, Parks and Recreation, Federal and State departments, Professional Planner, Sustainability Director, Zoning Director/Administrator, Director of Housing and Business Development, Energy Procurement Manager, Stormwater

manager, Public Works Director, Engineer, Public Service Director, Permitting Authorities, Municipal Separate Storm Sewer System (MS4) Program Coordinators, Stormwater Plan Reviewers, environmental laboratories (governments, universities, and other research institutions), water quality and weather forecast modelers.

7.3 Adaptation Needs: Research, Planning, and Policy

- Expand horizon of temporal and spatial planning windows
- Inventory and assess stormwater management systems that need to be altered to handle heavy precipitation
- Replace and separate combined sewer and stormwater systems
- Increase performance of current water quality treatment systems
- Current systems are based on historical figures and most of them are based on a 10-year 24 hour storm, which is calculated based on the maximum amount of rainfall in one day, but with increasing precipitation, it may be necessary to use a different approach—such as using a 100-year event as the baseline
- Economic and environmental analysis of climate change impacts on conventional versus low impact development, or green stormwater infrastructure
- Develop models and tools that assess public health impacts, such as risk of waterborne illness associated with combined sewer overflows and vulnerability to extreme heat.
- If planners intend on using "real-time management" then rainfall statistics need to be updated so they are based on current figures, and information for designs needs to be updated due to the fact that most designs rely on the Technical Publication 40, which is around 40-50 years old. In short, planners need access to current rainfall statistics.

7.4 Adaptation Needs: Education and Training

- Need for increased education on effects of urbanization on local hydrological systems
- Use conservative figures when configuring how to deal with increasing intensity of storms
- Work to improve the efficiency of current systems using models or by closely monitoring the situation
- Built better system towards using "real-time management"
- Education on uncertainty involved with prediction of increased rainfall
- Education involving what the phrase "10 year high" and "100 year event" really mean
- Monitoring of stormwater management systems
- Networks of planning professionals for information exchange

8. ECOSYSTEM-BASED MANAGEMENT

Human use, socio-economic impacts, and climate change must now be considered alongside longstanding issues of habitat conservation and water quality. Ecosystem based management (EBM) has been developed in response to this need. "EBM accounts for both ecological and socio-economic factors as well as their cumulative impacts on a management area. EBM provides for geographically specific, holistic resource management of habitats, species, and ecosystem level effects of resource use, such as food web impacts" (MRAG 2008). Since such a management approach is inherently transboundary, stakeholder engagement strategies are also needed (Quigley et al., 2009). For a comprehensive listing of avenues for engagement, as well

as a template for addressing social inequity, see the Draft Michigan Environmental Justice Plan (2009).

Political, socioeconomic, ecological, and institutional boundaries
EBM needs relating to political, socioeconomic, ecological, and institutional dynamics are largely grouped into two areas:
- Needs relating to a lack of resources and administrational or political hindrances. (jurisdictional or governance issues)
- The need to strengthen collaboration between different local, state, and federal agencies with different institutional climates and mandates.

Specific barriers to climate adaptation:
Barriers to Federal Attention to Adaptation
- Lack of Federal Leadership
- Lack of Funding
- Political Opposition
- Ignorance
- Lack of Intra- and Inter-Agency Coordination
- Competing Priorities
- Lack of Adaptation Mandates
- Legal Obstacles

Barriers to State Adaptation Planning
- Lack of federal guidance
- Lack of state-level leadership
- Lack of state and regionally specific scientific information
- Budget constraints
- Reliance on historical conditions
- Lack of public awareness, engagement, and pressure

8.1 Climate Impacts
- Earlier ice breakup and earlier peaks in spring runoff will change the timing of stream flows and increases in heavy rainstorms may cause more frequent flooding.
- Reduced summer water levels likely to diminish recharge of groundwater supplies, cause small streams to dry up, and reduce the area of wetlands, resulting in poorer water quality and less habitat for wildlife.
- Drought and lower water levels might ultimately increase ultraviolet radiation damage to aquatic organisms, esp. in clear shallow water bodies.
- River flooding may become more common and extreme because of the interaction of more frequent rainstorms with urbanization and other land management practices that increase the pavement and other impervious surfaces and degrade the natural flood absorbing capacities of wetlands and floodplains. The result could be increase in erosion, additional water pollution from nutrients, pesticides, and other contaminates, and potential delays in recovery from acid rain.

- Land use change and habitat fragmentation combined with climate change induced shrinking of streams and wetlands will also decrease the number and type of refuge available to aquatic organisms.

8.2 Relevant Roles

Mayors, City Councils, Planning of Zoning Commissioners, City and County government staff Sustainability Officer, Environment Quality Manager, Zoning Director, Energy Procurement Manager, Engineer, Architect, Director House & Business Development, human services, emergency preparedness, City Forester, Port Directors, Parks & Recreation staff, Federal and State departments, environmental NGOs, non-profit organizations, architects.

8.3 Adaptation Needs: Research, Planning, and Policy

- Baseline data against which to compare subsequent data
- Research on ecosystem processes
- Relationships between impacts and coastal stressors - identify spatial and temporal thresholds affecting the adaptive capacity and biotic integrity of ecosystems
- Population assessments for key species incorporating spatial and temporal considerations
- Long-term data sets on human and ecosystem health
- Standards for data collection and reporting (such as in an online data clearinghouse)
- Indicators to track the state and health of the ecosystem and to evaluate the effectiveness of EBM
- High resolution field measurements of bathymetry, elevation, and substrate types in coastal areas at the land-water interface, to improve current digital elevation models
- Identify and prioritize coastal ecosystems in need of conservation and protection
- Verifiable predictive models and spatial tools assessing ecosystem impacts and vulnerabilities that reflect changes in hydrology, stormwater runoff, water quality etc. to inform policy, permitting, and design standards for stormwater, wastewater, and drinking water, move away from relying on historical data as a benchmark
- Lake level forecasting
- Integrative ecosystem models and other decision support tools to link ecosystem services with human impacts and responses
- Actionable science from federal agencies
- Downscaled climate change information to relevant scales
- Increased collaboration with local universities
- Increased networking for exchange of knowledge and experiences
- Financial support for regional and local adaptation
- Address the real and perceived competition between mitigation and adaptation
- Avoid regulatory and cross-jurisdictional conflicts
- Political support for integrated management
- Clear management objectives
- Better communication of EBM principles to the public
- Integrate management and increase communication/coordination/cooperation within and between agencies, NGOs, and other organizations and across jurisdictions
- Clarification of fundamental terminology and data to interagency managerial practices
- Engaging community and stakeholder groups in decision-making

- Developing methods for establishing multiple use lake/shore zones
- Developing methods for implementing ecosystem approaches to fisheries management
- Advancing coastal land use practices by accounting for land-sea interactions in land use decisions
- Adaptive strategies that retain management flexibility in the face of uncertainty
- Conservation policy and planning initiatives incorporating current and future climate change science and impact assessment in an adaptive management approach
- High resolution forecast modeling of regional precipitation patterns, watershed hydrology, predict flooding, runoff intensity, and assess impacts on agricultural practices and stormwater to inform design standards, and siting criteria for utilities (stormwater, drinking water intakes, etc).

8.4 Adaptation Needs: Education and Training

- Increased data and tools focusing on local, species, and ecosystem-level data
- *Challenge is a lack of resources--funding, training, and time--to use tools
- Accurate and verifiable predictive models and spatial tools (geographic information system or GIS software, layers, and remote sensing)
- Need for EBM professional development training
- Training on how to incorporate dynamic ecosystem processes or ecological sustainability into EBM decision-making
- Training on how to plan, develop, and implement an EBM approach to management
- Practical applications and real-world examples of EBM, including examples of success and failure, and how EBM worked, caused the problem, or may have thwarted a problem if implemented
- New and different tools/strategies for varied audiences (technical, management, stakeholders, public)
- Collaborative research addressing the needs of decision-makers and natural resource managers
- Public dialogue on potential climate change impacts and adaptation strategies to support incorporation of climate change research into policy and planning
- A preferred training format would be for participants from a particular place to learn how to formulate a strategic plan for implementing EBM

8.5 Specific Issue Areas

8.5.1 Watershed planning and land use

<u>Climate Impacts</u>

- Earlier ice breakup and earlier peaks in spring runoff will change the timing of stream flows and increases in heavy rainstorms may cause more frequent flooding.
- Changes in timing and severity of flood pulses are likely to reduce safe breeding sites, especially for amphibians, migratory shorebirds, and waterfowl, and may cause many northern migratory spp. i.e. Canada geese to winter further north.
- Reduced summer water levels likely to diminish recharge of groundwater supplies, cause small streams to dry up, and reduce the area of wetlands, resulting in poorer water quality and less habitat for wildlife.

- Drought and lower water levels might ultimately increase ultraviolet radiation damage to frogs and other aquatic organisms, esp. in clear shallow water bodies.
- River flooding may become more common and extreme because of the interaction of more frequent rainstorms with urbanization and other land management practices that increase the pavement and other impervious surfaces and degrade the natural flood absorbing capacities of wetlands and floodplains. The result could be increase in erosion, additional water pollution from nutrients, pesticides, and other contaminates, and potential delays in recovery from acid rain.
- Land use change and habitat fragmentation combined with climate change induced shrinking of streams and wetlands will also decrease the number and type of refuge available to aquatic organisms, esp. those with limited dispersal capacities (i.e. amphibians and mollusks) as streams and wetlands shrink.

Relevant Roles
- Municipal and regional planner, stormwater manager, natural resource manager, policy makers, watershed organizations.

Adaptation Needs: Research, Planning, and Policy
- *Restore and Enhance Critical Near-shore Areas, Tributaries, and Connecting Channels:* The goal should be to reestablish the natural states critical to near-shore and tributary communities so they can once again perform their stabilizing function. If that is not feasible, enhance critical elements that play a role in stabilizing communities.
- *Remediate Basin-wide Sources of Stress:* Research on and implementation of control over new and existing invasive species, Mitigate existing negative impacts and prevent significant future human alterations of tributary hydrology and Great Lakes shoreline structure. This can include promoting connectivity of habitat (such as wetlands or free-flowing rivers) important for many species. Reduce loadings of nutrients, sediments and dredged material, toxic chemicals, and microbial pollution to the Great Lakes and tributaries from all sources, including addressing continued development pressures and potential for increases in polluted runoff.
- *Protect Healthy Functioning Elements:* Recovery of healthy near-shore communities and tributaries, once begun, must be maintained; the conditions that caused the impairments in the first place must be addressed. Watershed-based approaches to land use management provide the best opportunity to minimize negative impacts on the surface water and groundwater essential to the sustainability of the Great Lakes ecosystem. Actions should support and expand activities that employ holistic, watershed-based approaches to land and water use decisions. Conserve biodiversity.
- *Monitor ecosystem health and establish benchmarks for continued improvements:* Water quality monitoring, erosion control, assess conditions of stream, riparian, and estuarine habitats, catalog and assess impacts of development and other sources of environmental contaminant on watersheds and water quality. Identify remediation options; improved treatment or removal technologies, restore and maintain connections between wetlands and lakes or rivers. Identify spatial and temporal thresholds affecting adaptive capacity and biotic integrity.
- *Incorporate climate change into policy:* consider climate change trends and potential impacts information, such as projected changes in watershed distribution and functioning, into policy

and planning at various levels of government. Develop land use planning or policies that utilize human-directed adaptation to climate change to reduce impacts to Great Lakes systems. Develop land use planning and policy actions that protect the natural processes which create wetlands and maintain their ability to adapt to varying water level conditions.

- *Incorporate strategies to protect and restore ecosystems:*
  - Air quality improvement: Strategies to reduce heat trapping gas emissions have the ancillary benefit of reducing air pollution
  - Water quality protection and demand/supply management: Upgrade sewer and septic systems and contain nonpoint pollution from roads, farmland, and other dispersed sources. Combined Sewer Overflows (CSO) will be exacerbated by increases in heavy rainfall.
  - Urban and land use planning: Reduce sprawl to minimize habitat destruction and fragmentation.
  - Habitat protection and restoration: Rehabilitation of wooded riparian buffer strips; restoration of floodplain forests; wetland preservation and restoration; reducing extent of impervious surface; protect against invasive aquatic and terrestrial organisms; preserve or restore migration corridors; development regulations designed to minimize landscape fragmentation; preserve/restore migration corridors.
  - Aquatic Ecosystems, Resources, and Wildlife: Protect riparian zones of rivers, existing wetlands and headwater streams, groundwater systems, and lakes; Native species for restoration should be evaluated in terms of their suitability for a warmer climate and ability to withstand frequent floods and droughts; Water management policies that support conservation and reduce human demands for water, achieve by changing human behavior in households, farms, and industries.

8.5.2 Recreation

Climate Impacts

- Changes in the viability of recreational fishing could affect the region's economy.
- Shorter, warmer winters will result in losses in winter recreation (skiing, ice fishing, snowmobiling), but may lengthen the season for warm-weather recreation. Changes in recreational fishing, hunting, and wildlife viewing may occur as the distribution of species shifts across the region.
- Fixed docks will be too high, ramps will need to be extended, navigational hazards will be exposed.
- Climate warming may lower heating costs in winter, but higher costs for air conditioning in summer.
- Decreased water levels could reduce hydropower generation in region.
- More days with high heat may exacerbate the formation of dangerous levels of ozone. Ozone and other air pollutants generated by coal fired power plants in the region are likely to exacerbate asthma and other respiratory diseases.
- Health risks associated with extreme heat are likely to increase while cold related illnesses are likely to decrease.

Relevant roles

- Municipal and regional planner, storm-water manager, natural resource manager, policy makers, Chambers of Commerce, marinas, State tourism boards, tourism professionals, conservation organizations.

Specific Adaptation Needs

- Shoreline inventory and projections of lake level changes to assess needs for improvements to infrastructure (docks, ramps, navigational hazards).

8.5.3 Fisheries

Climate Impacts

- Lake levels are anticipated to decline.
- Declines in duration of winter ice expected to continue.
- Loss of winter ice may reduce winterkill in shallow lakes, but jeopardize reproduction of whitefish in the Great Lakes bays, where ice cover protects eggs from winter storm disturbance.
- Distributions of many fish and other organisms in lakes and streams will change. Cold water species (lake trout, brook trout and whitefish) and cool water species (northern pike, walleye) are likely to decline in southern parts of the region, while warm water species (smallmouth bass and bluegill) are likely to expand northward.
- Change in overall fish production in particular system could change sustainable harvests for all fish populations in the system.
- Changes in relative productivity of individual fish populations in particular system could change relative levels of exploitation that can be sustainably directed against the fish populations in the ecosystem.
- Large-scale shifts in geographic distribution of species could change the mixture of species that can be sustainably harvested within a specific geographic area and change location of profitable fishing grounds.
- Small-scale shifts in the spatial distribution of members of a specific population could change the sustainable harvest for the population and the efficiency of fishing gear, leading to change in sustainable levels of fishing effort.
- Invasions by native species currently found south of the region and invasions of warm water nonnative species, i.e. common carp, will be more likely, increasing stress on native animal populations and fisheries in the region.
- In all lakes, the duration of summer stratification will increase, adding to the risk of oxygen depletion and formation of deep water dead zones for fish and other organisms.
- Lower water levels coupled with warmer water temperature may accelerate the accumulation of mercury and other contaminants in the aquatic food chain and ultimately in fish.
- Many species will grow faster in warmer waters, but to do so must increase feeding rates. It remains uncertain whether prey species and the food web resources on which they depend will increase to meet these new demands.
- Water withdrawals from the Great Lakes are already subject of contentious debate, and pressures for more water for drinking, irrigation, and other uses may intensify conflicts as water shortages develop.

Relevant roles
- Municipal and regional planner, stormwater manager, natural resource manager, policy makers, fisheries staff, fisheries commissions and councils, Federal and State agencies.

Specific Adaptation Needs
- Reallocation of harvest from adversely affected populations
- Science based information to minimize uncertainty associated with setting sustainable harvest limits.
- Maintain exploitation rates at levels that include a safety margin based on historical uncertainties in fish stocks.
- Reduce negative impacts of other human induced stressors such as acidification and habitat destruction.
- Reduce over-investment in fisheries that exploit certain species at unsustainable rates.
- Ensure that no practice applied for a short time could produce extreme outcomes.

8.5.4 Invasive Species

Climate Impacts
- Invasions by native species currently found south of the region will be more likely, increasing stress on native animal populations and in the region.
- The geographic range of forest pest species such as gypsy moth is likely to expand as temperatures warm and the distribution of food plants changes.
- Changes in leaf chemistry due to CO2 fertilization are possible, reducing food quality for some organisms. This could cause some leaf-eating pests to eat more and could ultimately alter aquatic and terrestrial food webs.
- Crop losses may increase as invasive pests and diseases become established in the region and as warmer longer growing seasons facilitate the buildup of larger pest populations. Already the range of the bean leaf beetle, a pest of soybeans, appears to be shifting northward.

Relevant roles
- Municipal and regional planner, storm-water manager, natural resource manager, policy makers, fisheries commissions and councils.

Specific Adaptation Needs
- Extensive observational and experimental studies or observational studies of performance of invasive species in many different geographic locations and correlating its performance with biotic and environmental variables in those areas.
- Studies examining whether climate change will increase the susceptibility of ecosystems to invasion.
- Managers will need climate information as it relates to pathways, prediction and risk analyses and monitoring for terrestrial and aquatic invasive species.
- States need information on how the effects of climate change (e.g., changes in precipitation patterns and temperature) interact with vectors and pathways of invasive species transport.
- Develop, establish, and fund strategically placed and comprehensive monitoring systems; integrate and coordinate systems among states; design monitoring systems to incorporate

the potential effects of climate change especially temperature and precipitation changes that influence climatic boundaries; establish monitoring baselines to detect changes in climate and invasive spp.; develop core of indicators for managers to use when monitoring invasive species under changing conditions.
- Develop early detection and rapid response (EDRR) efforts under changing climate conditions. Need to understand EDRR capabilities (authorities, emergency powers, broader control capacities and develop protocol for early detection and removal).
- In general, research needed to examine and understand pathways and vectors, establishment and dispersal, ecosystem susceptibility and interacting stressors (i.e. land use change, fishing, overpopulation).

9. COASTAL PLANNING AND MANAGEMENT

The need to downscale information is a common theme for coastal planning. However, the need for regional data to be useful locally requires making data accessible for local planning purposes. The 2006 report from Desotelle identified needs, barriers, and solutions within the basin on both regional and local scales. Leadership, tools and data are listed as broader regional needs; awareness, communication, data sharing and access are listed as local needs (Desotelle, 2006:22-23). To emphasize the emerging trend towards ecosystem based management, a summary of needs for the coastal management community are:

"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, 2009).

As for downscaling information and its accessibility to the end-users in coastal communities, "the need for real time monitoring is also particular to a changing climate; reliance on past averages to as a primary planning reference is no longer sufficient. The National Federation for regional associations for coastal and ocean observing describe the need to support adaptive management through regular synthesis of coastal data. 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, Thompson and Scholz, 2005:17).

Furthermore, research barriers have been characterized as "the lack of a robust relationship between the extension and research components of Sea Grant hinders the development of a research agenda that effectively addresses coastal citizens' needs. It was agreed that our SCCD Extension colleagues must contribute directly to forging relationships with researchers who can produce rigorous, fundable proposals that meet clearly defined SCCD research needs.

"Some of the proposed solutions include making outreach a requirement for Sea Grant research funding and pairing outreach educators to related research projects. SCCD educators should

become more involved in the research process, by recruiting researchers and identifying proposal reviewers at both state and national levels. SCCD faculty should also partner as co-PIs with full-time research faculty to develop relevant applied research projects" (SCCD, 2008).

The National Estuarine Research Reserve System (NERRS) Science Collaborative provides a mechanism whereby NERRS-based science can be put to work in coastal communities address coastal resource management challenges including climate change adaptation. Administered by the University of New Hampshire (UNH), the program funds and supports Reserve-led research projects that bring scientists, intended users of the science, stakeholders, educators, and trainers together to address problems related to coastal pollution and habitat degradation in the context of a changing climate.

The NERRS Science Collaborative uses a competitive process to identify, fund, and foster science to address local environmental challenges with broader relevance. Projects are selected through annual competitions, designed to insure that research project teams, intended users of the science, and relevant stakeholders work together to describe science and technology needs to address specific problems, define research questions, design and implement projects, and apply the results. The program works with coastal science outreach specialists, trainers, and communicators to share information about the science that it funds—not only research results, but also methods, collaborative practices, and evaluation tools—with other reserves and the broader coastal management community.

Political, socioeconomic, ecological, and institutional boundaries

Specific barriers to climate adaptation:

- Downscaling of information and implementing ecosystem based approach
  - Federal level: intra- and inter-agency coordination, lack of leadership
  - State level: coordination, program funding, prioritization
  - Regional level: coordination, downscaling information
  - Local level: data accessibility, local relevance of regional data

9.1 Climate Impacts

Strong storms, high winds, heavy wave activity, freezing and thawing of lake ice can all contribute to shoreline erosion. Changes in shoreline access as lake levels decline and/or fluctuate and shorelines erode may deteriorate quality of public beaches and other public and privately owned access points. As precipitation events become more extreme, storm and waste water overflow may result in poor water quality, and increase risk to public health and safety.

9.2 Relevant roles

Professional planners, land use planners, sustainability director, zoning director/administrator, emergency management director; stormwater managers, natural resource managers, environmental information services, property owners, developers, State tourism boards, policy-makers, Representatives on State Legislature Natural Resource and Environment committees, Staff on State and County Departments of Natural Resources, Environmental Quality and Protection, government and university research institutions.

9.3 Adaptation Needs: Research, Planning, and Policy

- Intra- and inter-agency coordination
- Data distribution and accessibility
- Data coordination
- Regional modeling and information downscaling: regional to local relevance
- Modeling data for fluctuating lake levels
- Real-time monitoring
- Spatial planning tools, coastal and marine spatial planning for ecosystem based management
- 48 hour forecasting ability for coastal conditions
- Monitoring/observation stations and systems
- Inventories
- Risk and vulnerability assessments
- Prioritization
- Immediate adaptation action
- Adaptation mandates
- Change legal constraints
- Funding for programs
- Improved methods for estimating coastal erosion
- Public outreach and education
- Land use and land use change
- Erosion rates, erosion hazard and flood areas, potential of catastrophic rise in lake levels
- Enhance current policy and regulatory mechanisms for shoreline erosion
- Coastal area restoration
- Regional information
- Education planning
- Mechanisms for determining public access, recreation needs
- Reconcile competing recreation needs
- Parks and recreation program funding
- Increase and maintain public access to Great Lakes shorelines
- Boardwalks, trails, parks, beaches, piers
- Need for in-depth interviews with end users of programs
- Mechanisms to evaluate trade-offs between human and environmental needs
- Technical tool transfer between state and local governments, and property owners
- Increase national funding, leveraged with state and local resources
- Funding for vulnerability and adaptation research, planning

9.4 Adaptation Needs: Education and Training

- Intra- and inter-agency coordination
- Data distribution and accessibility
- Data coordination
- Monitoring and information downscaling: regional to local relevance
- 48 hour forecasting
- Citizen education

- Ecosystem information
- Coastal ecosystem complexity: human and natural system interaction
- Participatory and informed decision making
- Decision support tools and mechanisms for accessibility
- Ecosystem based management training (EBM)
- Advanced facilitation
- Land use planning and regulation
- Technical planning tools
- Economic development
- Low impact development
- Zoning
- Conservation design
- Coastal development
- Smart growth
- Coastal and marine spatial planning for ecosystem based management
- Conducting needs assessments
- Shoreline erosion control

9.5 Specific Issue Areas

9.5.1 Shoreline Erosion

Case: Wisconsin
"(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." (Wisconsin Needs Assessment, 2006). "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" (p. 10), which has implications for land use planning, property owners, and land development.

"Portions of Wisconsin's coasts are at risk of episodic erosion. Unsound development in these hazardous areas can lead to catastrophic events. In 2002, the Village of Oliver, in Douglas County, experienced some severe slumping along the St. Louis River. Seven properties were affected. One of the properties experienced a large ground failure, with an 18-foot scarp approximately one foot from the rear entrance of the home. With assistance from Wisconsin Emergency Management, the Village of Oliver acquired and demolished three of the affected properties. In a separate event, a home in the City of Superior experienced land subsidence in 2001, when the entire yard started moving toward the Nemadji River. Erosion from spring floods caused the ground within fifteen feet of the house to slide downhill; the City of Superior bought the structure and demolished it." (p.10).

The danger of using past averages of lake levels is exemplified in this issue as a concern for property owners. In Wisconsin, "coastal erosion and flooding have caused millions of dollars of property damage. Potential damages in the future may be even higher. Growth along the coast has outpaced growth within the state as a whole. Property owners are replacing smaller homes

with larger ones. Urban infrastructure sited using antiquated lake levels may be vulnerable to future damage, as well." (p.17)

Wisconsin is a good candidate for erosion research, as it is undeveloped in many areas. "Lake levels are slightly below average, making this a good time to examine and implement development tools. Existing management strategies are insufficient to direct development away from hazards. The needs assessment suggests that more information about hazards and more outreach are needed. The priority ranking for this issue area remains high." (p. 17).

The Wisconsin assessment lists the general need for tools: mapping, GIS, and tracking of hazard areas (p. 14) with the stated goal to "develop and implement shoreline and bluff erosion policies." (p. 18)(Wisconsin Needs Assessment and Strategy, 2006).

Case: Ohio

The Lake Erie Shoreline Erosion Management Plan Local Community Needs Assessment (2007) indicates that property owners would like basic training in controlling shoreline erosion, but that there was a level of mistrust of sources of information and data. In this assessment the needs are categorized as 1) Plans and Permits, 2) Financing Structural Solutions, 3) Best Management Practices, and 4) Understanding Lake Erie Erosion.

Several key themes emerged in this study when recruiting for focus groups. First, that eliciting response for participation was initially poor because people believed the study to be a telemarketing scheme. This changed as the research team asserted affiliation with a University, and were able to establish a level of trust. Second, some property owners do not trust the Department of Natural Resources, and refused to participate in the focus groups. Third, that 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. Developers were not included in this study.

<u>Relevant Roles</u>

Professional Planners, Sustainability Director, Stormwater Manager, Emergency Management Director, Natural Resource Manager, Representatives on State Legislature Natural Resource and Environment committees, State Departments, environmental laboratories (governments, universities, and other research institutions), property owners, developers, architects.

<u>Specific Adaptation Needs</u>

- Spatial planning tools, coastal and marine spatial planning as tool for ecosystem based management
- Tools, modeling; 48 hour forecasting ability for coastal conditions
- Monitoring and observation stations and systems
- Decision support
- Mechanisms to evaluate trade-offs between human and environmental needs
- Technical tool transfer between state and local governments, and property owners
- Increase national funding, leveraged with state and local resources

- Funding for vulnerability and adaptation research, planning
- Best management practices

9.5.2 Recreation and Tourism

Tourism as an industry has unique planning needs for seasonal climate and weather information, both regional and local scale; and timely accessibility to that information (Huntley, 2009). Public beaches and shoreline access sites were inventoried for Wisconsin (WNA, 2006). There are different types of recreation: land, lake, river based, and vary by season: warm and cold weather activities have very different weather requirements. Climate change will effect each of these recreation categories differently. Information gathered for the Wisconsin needs assessment showed increased demand for: coastal boardwalks and trails, parks, public beaches and fishing piers. Barriers for Wisconsin recreation are: 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 (WNA, 2006). Although there remains a dearth of literature in this area[15], 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 highlighted here also (Patz et al., 2008).

Climate Impacts

Changes in shoreline access as lake levels decline and/or fluctuate and shorelines erode may deteriorate quality of public beaches and other access points. As precipitation events become more extreme, storm and waste water overflow may result in poor water quality, and increase risk to public health and safety. Impacts on the tourism industry will vary depending in region and locality, and different age and income groups will likely change preference for climate and location for tourist destinations (Lise and Tol, 2002).

Relevant Roles

Planner, Sustainability Director, Stormwater Manager, Emergency Management Director, Natural Resource Manager, Beach Managers, Representatives on State Legislature Natural Resource and Environment committees, State Departments, State tourism boards, environmental laboratories (governments, universities, and other research institutions); water quality, weather forecast, and regional climate modelers.

Specific Adaptation Needs

- Regional and seasonal weather forecasting
- Communication with tourism community (both hosts and travelers)
- Access to and use of water quality data
- Separation of combined sewer systems
- Ecological forecasting
- Land and wetland conservation design
- Methods for shoreline erosion control
- Decision making organizations need to understand implications of their actions on the ground.

[15]For further discussion on beaches, forecasting, and public health, see Sturtevant (2004) and the Report on Great Lakes Beach Health (2005) listed under the Coastal Planning references of this report.

- Training for regional directors about issues of beach closures
- Rapid test methods, predictive models and real-time data for prediction of beach closures
- Training and standardized survey design and test methods
- Educate public and government about the issues using local town meetings as a forum
- Educate the public by developing strong outreach products.
- Create awareness on how to be responsible beach goers.
- Use Sea Grant Extension agents to aid public in understanding beach closure issues.

Communication
- Establish two way communication network between local beach managers and federal scientists and researchers.
- Establish network for beach managers to continue discussion on emerging technologies, new training devices, etc.
- Develop better web tools to maintain open communication lines in the region.

10. HAZARD RESILIENCE AND DISASTER PREPAREDNESS

The resiliency of a community, or system, is its capacity to adapt to potential hazards in order to achieve and sustain a level of functioning and structure (NOAA/CSC 2006). Great Lakes coastal communities are subject to hazards associated with climate change including: increased number and severity of coastal storms, risk of oil spills in select regions, and other natural and human hazards that have major implications on human safety along with the economic and environmental health of coastal areas. Management issues include community preparedness, management information needs, planning, training, and public communication and education. Despite concerted efforts by scientific and coastal management communities, there remains a strong need to increase community resilience to coastal hazards (NOAA/CSC 2007; 2008).

A 2010 study commissioned by the NOAA Coastal Services Center identified benefits and barriers that local land use planners face when considering whether to implement hazard mitigation planning. This study produced a compact list of benefits, and a much lengthier list of barriers.

Benefits identified tend to relate to the desire for professional satisfaction. Identified benefits include:
- Intrinsic satisfaction
- Saved lives and reduced economic losses
- Compliance with Federal and State mandates
- Meeting political and public demand, where existent

Barriers to hazard and resiliency planning tend to be more external. Barriers include:
- Lack of public support or political will
- Limited budgets
- Competing priorities
- Limited actionable data
- Disconnect with emergency planners and limited follow-through

- Existing development and property rights
- Bias in favor of growth

10.1 Climate Impacts

Flooding

Climate change in the Great Lakes area is expected to bring more intense episodes of precipitation (rain, snow, sleet) so more frequent episodes of flooding are also predicted. However, current infrastructure for stormwater may not be sufficient to handle the intense episodes of precipitation, which has implications for both flooding issues and water quality. Even areas that traditionally do not experience flooding may experience episodes of flooding, so this is an issue of importance to coastal communities in the Great Lakes.

Hazard Communication/Information/Alert Systems

One predicted effect of climate change is an increase in hazard related events, such as flooding and more intense storms. These changes require organized systems for hazard communication, information, and alert systems. This means that all citizens will need to be able to quickly access urgent hazard related information in an effective manner. However, information on this topic is limited. For this review, only a few references to this topic was found within papers related to flooding, so it is clear that this topic is in urgent need to be addressed by local communities and states.

Urban Heat Island Effect (UHI effect)

UHI effect is the effect that occurs when air temperatures in cities are 3.5-4.5 degrees C higher than surrounding rural air temperatures. This is caused by a concentration of buildings and roadways, which absorb a large percentage of electromagnetic energy from the sun and reradiate large amounts of heat. It is also compounded by the lack of vegetation in urban areas, since vegetation can provide shade and other cooling effects to the surrounding areas. UHI effect has implications for environmental justice and health issues since in extreme heat events, those most likely to suffer and face higher mortality risks are the elderly, the sick, and the poor. Since the UHI effect is predicted to cause a 1 degree C increase in urban air temperatures each decade, this is an issue that needs to be addressed in urbanized areas.

10.2 Relevant Roles

Consistent with a community-based social marketing approach the NOAA CSC hazard resilience report recommends segmenting and prioritizing audiences for climate change adaptation training to maximize the potential of achieving behavior change between 1) planners, 2) elected officials, or 3) the general public. This report identifies planners as the best target audience among these three for NOAA. Planners participating in that study indicated they are already seeing some effects of climate change. These include effects on agriculture, septic systems, and flooding of coastal properties. In some cases, land-use planners reported that residents were becoming concerned about these effects. While awareness of these issues among the public and elected officials is increasing, it is still not high.

Other audiences for hazard resilience and disaster preparedness training include:

- Real estate agents
- Developers
- County Emergency Director
- City Manager
- Emergency management and response (e.g., fire rescue, police)
- Public Works
- Parks and Recreation
- Federal partners with FEMA (in unusual cases, to address broader effects)

10.3 Adaptation Needs: Research, Planning, and Policy

- Tools related to natural systems and climate change, mostly sea level rise and storm surge data and prediction.
- Increased need for hazard resilience products or services.
- Tools related to multiple scenarios, vulnerability mapping, assessment, forecasts, and visualization.
- Sedimentation related tools.
- Changes in coasts including development need to be included in hazard related tools and datasets.
- Detailed information on the economic, environmental, and social benefits of hazard and resiliency planning.
- High resolution data.
- Predictive models to illustrate the evolution of coastal features under various scenarios.
- Predictive models related to public health impacts including waterborne illness and heat vulnerability.
- Hazard mitigation and land use planning to limit development of hazardous areas.
- Guidance or assistance for communities on how to implement policy changes in the immediate aftermath of a disaster, when public and elected official attention is high as is receptivity to change.
- Guidance for communities on how to address existing development and property rights issues related to hazard resilience.
- Impacts of climate change on water quality.
- Community specific data.
- More studies focusing on socio-economic effects associated with climate change.
- 100 year flood maps need to be updated to reflect changes.
- Improved disaster management and planning, and also disaster preparedness training.
- Return on investment in terms of reducing damages and economic losses from flooding and improving water quality.
- Decision makers need better information about how different erosion control options affect regional resiliency and water quality (CICEET 2007).
- Better communication of the importance of economic drivers for erosion control policies. This includes quantification of the costs and benefits of non-structural erosion control techniques, and better integration with FEMA policies and insurance practices.
- Primary research to better understand and delineate barriers and benefits to hazard mitigation among decision-makers and planners.

- Local hazard resiliency studies that examine trend in local hazards.
- Planning horizons need to be widened from a typical window of only 6 months to 5 years in order to be able to deal with climate change, and implicitly hazard mitigation planning issues.
- Hazard mitigation plans need to be developed in such a way so that they limit development in hazardous areas, which can be done through a number of ways including zoning ordinances, prohibition, and transfer of development rights.
- Hazard mitigation plans can be extremely difficult to carry out due to the complexity of the plans and the number of stakeholders and agencies involved, so increased communication between stakeholders and agencies is necessary.
- Increased communication with planners about the benefits of hazard mitigation plans is necessary in order to implement plans without Federal mandates.
- Increased funding is needed in order to create and implement hazard mitigation plans and to assure that every community has access to required tools and training.
- Hazard mitigation planning should become a Federal requirement in order to give states the incentive to create and execute hazard mitigation plans.
- Land use standards should not conflict.

Communication

- Need for increased inter-agency communication and collaboration at regional, state, and local levels.
- Risk and vulnerabilities communication related to storm surge need to be improved.
- Climate change planning and policy efforts should be coordinated between states.
- Hazard and emergency agencies should increase communication, data-sharing and coordination with one another on the local, state, and federal level.
- Improve channels of communication between emergency planners and land use planners.
- Improve communication of risks and hazards to public and decision-makers.
- Public support in favor of development are one of the main reasons why hazard mitigation plans are often not on political agendas, but increasing public education on the benefits of hazard mitigation plans can bring political attention to developing and implementing policies related to hazard mitigation.
- It is necessary to communicate the importance, need, and benefits of hazard mitigation planning to both politicians and planners.
- Increased communication and awareness of grant opportunities are necessary to fund hazard mitigation planning.
- Increased need for collaboration with local NOAA representatives and land use planners, and training for planners on how to utilize and access resources.
- More support is necessary in training planners to educate politicians, the public, and other decision makers on the benefits of hazard mitigation planning.
- Land use planners need more assistance in forming communication networks with emergency planners.

10.4 Adaptation Needs: Education and Training

- Need for increased education on effects of urbanization on nearby hydrological systems (especially related to increased flooding, water quality degradation, base flow decrease issues).
- Educate community planners on the above issues and some options for dealing with the predicted effects:

    - Use a conservative figures when configuring how to deal with increasing intensity of storms.
    - Work to improve the efficiency of current systems using models or by closely monitoring the situation.
    - Built better system towards using "real-time management."
- Education on uncertainty involved with prediction of increased rainfall.
- Education involving what the phrase "10 year high" and "100 year event" really mean?
- Important to stress the close monitoring of stormwater management systems in order to ensure they are functioning as assumed.
- Networks of planning professionals for information exchange
    - Water resource decision support systems
    - Model ordinances and BMPs
- Local-specific data and case studies that are actionable from a planning perspective; maps were seen as useful, but even more so the data that underlie these maps.
- BMPs and guidance for dealing which changing lake levels.
- Expert advice and guidance in locating, interpreting, and using available data.
- Encourage planners to see the development or renewal of master plans as an opportunity to conduct risk or resiliency planning. Document and publicize successes in this area to encourage planners to take advantage of these natural windows of opportunity.
- Training delivery mechanisms for planners:
    - Webinars
    - Local studies
    - Conferences
    - Local interaction with NOAA representatives in each region.
    - Others: social media and networking tools including listserves, APA, conferences, web portals, e-newsletters.
- Resources currently used by planners: state programs, digital coast images, LIDAR, Flood Smart, DisasterSafety.org, CanVis software.

10.5 Specific Issue Areas

10.5.1 Storm Surge

<u>Specific Adaptation Needs</u>

- NOAA's SLOSH model, the primary source for data related to storm surge, needs to be updated so that the data takes into account development and other changes that have taken place along the coasts.
    - Communicating uncertainty related to the forecasts is necessary, and could be done by running the SLOSH model in several different scenarios and sharing the result.
    - Improvement in storm surge forecasting is necessary, and in order to accomplish this it may be useful to integrate data from several different models.
- Socio-economic benefits of utilizing forecasting and other storm surge related tools is necessary.
- Tools specific to Great Lakes storm surges need to be developed, because the main model, SLOSH, is related to mostly hurricane activity along the Atlantic and Gulf coasts.

Communication

- Improving storm surge forecasts capacity to 48 hours before landfall is a pressing need
- Improving communication and presentation of storm surge forecast results is necessary, and may be done using an easier to interpret format.
- Increased communication of full suite of NOAA storm surge models is necessary so that state and local users are aware, and so that private and public sector users also have access.
- Need for increased intra-agency collaboration and collaboration between agencies and local users.
- Increased outreach is necessary in order to educate the public, planners, and policy makers on forecast uncertainty..
- Increased training related to storm surge modeling and forecasting is needed by emergency and land use planners and extension workers.

10.5.2 Flooding

Specific Adaptation Needs

- A master plan is necessary in order to highlight community land use goals
- Ordinances prohibiting development in flood zones should be developed in order to decrease flooding costs and hazards.
- Plans to purchase land in floodplains and turn them into parks or open spaces should be constructed in order to decrease costs associated with flooding.
- There needs to be increased accessibility to tools that illustrate the extent of the floodplain so that decision makers can decide where to develop.
- Improved permitting systems and regulations to help mitigate erosion.
- Mitigation of coastal hazards created by erosion (CICEET 2007; NOAA/OCRM 2006). Improved communication between government agencies involved in resiliency planning, i.e., public works departments, emergency management agencies, and planning departments.
- Local and customized forecasts and models.
- Increased communication of flooding risks associated with climate change.
- Increased access to information that assists coastal communities mitigate and understand issues related to storms, flooding, changes in lake levels, and climate change.
- More information should be available for community planners regarding mitigation strategies involving structural and land damage caused by storms.
- Increased education on the costs and benefits of flood insurance.
- For those who live near levees, it is important to know what levees are, how they work, where they are located, how they can be breached, and how to tell if the levee is vulnerable to collapse.
- Important for the public and policy makers to understand risks related to flooding, stressing that flood risk does not remain static over time.
- The cost associated with mitigation and the cost associated with cleaning up floods afterwards should be communicated so that the public and decision makers can understand the justification for mitigation since it tends to be much cheaper.
- Increased awareness of the meaning of 100 year floods; Citizens and decision makers should know that it refers to the chance of having a specific intensity of flood in one year. This means

that a one hundred year flood has a 0.01% chance of happening every year, not that this type of flood can only occur every 100 years.
- Locally customized forecasts and models.

10.5.3 Hazard Communication, Information, and Alert Systems

Specific Adaptation Needs

Communication

- Citizens need to be educated on where to find information related to information on emergencies and evacuations.
- It is necessary for more communication to the public on how to prepare for flooding, including precautions and evacuation preparedness.
- Gap in communication between departments and agencies, better communication channels needed between local planners, public works, emergency managers.
- Flood warning systems need to be developed along with flood emergency evacuation plans and flood preparedness systems.

10.5.4 Urban Heat Island Effect (UHI effect)

Specific Adaptation Needs

- UHI effect is expected to increase with climate change, so mitigation strategies are necessary to develop for urbanized area.
- Mitigation plans should include strategies to minimize impacts of buildings and roads or to increase vegetation, such as planting trees, building with lighter materials that absorb less energy, and planting vegetation on rooftops.
- Mitigation plans need to be community specific.
- Mitigation plans need to be developed collaboratively between decision makers, planners, and policy makers who are familiar with the local area, and environmental scientists and toolmakers.
- Tools should be developed that are specific to the local area, either by using an existing tool and adapting it to the local area, or by developing local tools.
- Technical issues need to be solved considering diverse and multiple actors and by considering issues in their local context (for example by considering local social and economic conditions, etc).

Communication

- Need for increased public awareness of the UHI effect.
- Need for increased education among politicians, planners, and other decision makers about the UHI effect and how to work to mitigate the effect.

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Appendix I

(Sources: NOAA survey responses from Great Lakes St. Lawrence Communities Initiative (GLSLCI) member communities in Ontario, Wisconsin, and New York [n=3]; to inform NOAA climate change adaptation mini-grant audience profile and issue identification, Feb 2010).

Relevant Roles--General

Knowledge and interests:
- Degree of knowledge on climate change impacts equivalent to average citizen
- Low to moderate awareness level
- Low familiarity with climate change terminology
- Degree of interest highly variable

Scale of work
Mostly at local/regional level, though some at the state/national level.

Potential climate change impacts having significant effect on Great Lakes coastal communities (+ indicates single response from survey participants):
- Lake level change +++
- Pressures on aquatic species+
- Decreasing snow pack in upper Great Lakes
- Coastal erosion +++
- River flooding +++
- Coastal flooding +
- Changes in extreme weather events +++
- Change in water quality +++
- Spread of new or existing invasive species ++
- Precipitation ++
- Drought+++
- Heat ++

Community assets/ activities that are most vulnerable to climate change (+ indicates single response from survey participants):
- Disaster preparedness and emergency response +
- Transportation+
- Capital investments+
- Budgets++
- Economic development +
- Ports+
- Energy++
- National security+
- Land use (+loss of public and private investment in infrastructure)
- Drinking water quality+++
- Drinking water infrastructure+++

- Stormwater infrastructure+++
- Wastewater infrastructure+++
- Shoreline infrastructure+++
- Wetlands++
- Streams and rivers++
- Beaches and coastal ecosystems+++
- Public health ++

By Question:

1) Which potential climate change impacts will have the most significant effect on your own and/or other Great Lakes coastal communities?

GLSLCI community in Ontario:
"Lake level changes, coastal erosion, river flooding, changes in extreme weather events (e.g., very high and sustained winds), changes in water quality, spread of invasive species, precipitation, drought and, of course, heat."

GLSLCI community in New York:
- Lake level change
- Pressures on aquatic species
- Coastal erosion
- River flooding
- Changes in extreme weather events
- Change in water quality
- Spread of new or existing invasive species
- Precipitation
- Drought

GLSLCI community in Wisconsin:
- Lake level change
- Coastal erosion
- River flooding
- Coastal flooding
- Changes in extreme weather events
- Change in water quality
- Drought

2) What community assets/activities are most vulnerable to climate change?

GLSLCI community in Ontario:
"All of those assets/activities listed, with land use including loss of public and private investment in buildings and structures, including road infrastructure."

GLSLCI community in New York:
- Budgets
- Energy
- Drinking water quality
- Drinking water infrastructure
- Stormwater infrastructure
- Wastewater infrastructure
- Shoreline infrastructure
- Wetlands
- Streams and rivers
- Beaches and coastal ecosystems
- Public health

GLSLCI community in Wisconsin:
- Ports
- Drinking water quality
- Drinking water infrastructure
- Stormwater infrastructure
- Wastewater infrastructure
- Shoreline infrastructure
- Beaches and coastal ecosystems