CLIMATE READY GREAT LAKES

by

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A project submitted
in partial fulfillment of the requirements
for the degree of
Master of Science
(Natural Resources and Environment)
at the University of Michigan
April 2011

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ABSTRACT

The Great Lakes region is predicted to experience significant coastal impacts due to global climate change that are different than impacts being predicted for our ocean coasts. Specialized education, training and community planning are needed to assist Great Lakes coastal communities in adapting to changes resulting from climate change. To help address these needs, students from the University of Michigan's School of Natural Resources and Environment collaborated with NOAA Great Lakes Regional Collaboration team members and Sea Grant professionals to develop training materials on adaptation to climate change in the Great Lakes region. The project resulted in three educational modules that can be delivered individually or as a unit to prepare local officials to develop climate change adaptation plans for their communities:

Module 1: "Climate Impacts: What am I Adapting To?" summarizes recent climate change research results and long-term forecasts for climate change impacts.

Module 2: "How do I Develop an Adaptation Plan?" prepares leaders to identify and consider management actions necessary to respond to forecasted changes through climate adaptation plans.

Module 3: "What Tools are Available for me to Adapt?" familiarizes leaders with decision tools and science based resources needed to make coastal development, resource protection, and infrastructure decisions that that will shape their communities coastline and keep communities sustainable for the next 50-100 years.

These outreach modules were developed to allow use by Sea Grant Program Extension Staff, USDA Extension Staff, Coastal Zone Management Programs, and other trained outreach professionals who work with local community decision makers in the Great Lakes region. Modules were designed to allow for maximum flexibility and adaptability and can easily be modified to include future research and tools that increase the information useful for local decision makers.

ACKNOWLEDGEMENTS

Primary contributors to this report included Jennifer Day, Martin Jaffe, Brian Miller, Elizabeth Mountz, Dawn Nelson, Heather Stirratt, Rochelle Sturtevant, and Richard Wagenmaker.

This report also benefited greatly from the input of Anthony Acciaioli, Steve Brueske, John Cawood, Lynne Chaimowitz, Gene Clark, Keely Dinse, Leslie Dorworth, Heather Elmer, Stephanie Fauver, Sara Grise, Kimberly Hall, David Hart, Steve Hilberg, Jill Jentes, Doug Kluck, Frank Litkoppler, Barb Liukkonen, Josh Lott, Joe Lucente, Margaret Mooney, Mary Penney, Chuck Pistis, and Jesse Schomberg.

Funding for this project was provided by NOAA, the Sea Grant College Network, and the University of Michigan's School of Natural Resources and Environment.

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PROJECT METHODOLOGY

BACKGROUND

The *Climate Ready Great Lakes* project is a building block that will inform larger Great Lakes Regional Initiative climate projects as well as other projects, increasing capacity to address climate change in the Great Lakes region. By partnering with the Sea Grant Network, this project complements NOAA's $25,000 education mini-grant for communicating uncertainty and GLRI-funded climate change adaptation for state and local coastal managers. The 2010 Great Lakes Restoration Initiative Project Roadmap has a three-pronged approach: 1) baseline monitoring, data and research, 2) regional downscaling, and 3) education, communication and capacity building. *Climate Ready Great Lakes* provides the foundation for future GLRI work in the education, outreach and capacity building category.

Climate Ready Great Lakes supports the goals of NOAA and the Nation as expressed in NOAA's 2011 Annual Guidance Memo[1] and Next Generation Strategic Plan[2] as well as the National Ocean Policy[3]. NOAA's 2011 Annual Guidance Memo states that NOAA's long-term strategy for climate adaptation and mitigation is focused on objectives to ensure we can improve scientific understanding of the climate system, and then apply this knowledge using data, information, and products to support adaptation and mitigation choices. NOAA's Next Generation Strategic Plan includes two objectives. The first is to have a climate-literate public that understands its vulnerabilities to a changing climate and makes informed decisions; the second is to have resilient coastal communities that can adapt to the impacts of hazards and climate change. Finally, one of the nation's new National Ocean Policy's Areas of Special Emphasis (ASE) is Resiliency and Adaptation to Climate Change and Ocean Acidification. The objective of this ASE is to strengthen the resiliency and capacity of Great Lakes coastal communities and environments to handle the impacts of climate change.

The project was divided into ten working groups with each group consisting of University of Michigan students as well as professional members of the Great Lakes Regional Collaboration team, Sea Grant Network and relevant partners. Each team had one student and one professional lead. The ten working groups included: Literature review, Needs assessment, Tools inventory, Module 1: *What am I adapting to*, Module 2: *What is an adaptation plan?*, Module 3: *What tools are available to help?*; Pilot; Evaluation; Marketing; and Budget. The literature

[1] Lautenbacher, Conrad (2011), *NOAA Annual Guidance Memorandum*, National Oceanic and Atmospheric Administration
[2] NOAA Office of Planning and Integration (2010), *Next Generation Strategic Plan,* National Oceanic and Atmospheric Administration
[3] Executive Order (July 19, 2010) *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

review, needs assessment and tools inventory teams set the groundwork for creating the three educational modules. In addition to identifying the most current research and software relevant to climate adaptation, the team identified climate adaptation needs in Great Lakes communities. The pilot team spearheaded two workshops to gain feedback on module development from Great Lakes Regional Collaboration team members as well as Sea Grant Extension agents. The evaluation team synthesized results from the pilot meetings and provided a framework for future evaluation. The marketing team worked to create a consistent look and feel throughout the project and promote the modules to relevant stakeholders. Lastly, the budget team managed funds from the mini-grant and the University of Michigan, School of Natural Resources and Environment.

LITERATURE REVIEW

A literature review (Appendix 1) was conducted to provide a foundation for understanding the most current and relevant research on climate change adaptation. The document is broken down into seven categories. Each category includes an annotated bibliography covering the best examples and materials in that field. The literature covered both peer-reviewed literature and gray literature including NOAA reports, web data and presentation materials. The categories were chosen based on relevance to the goals and objectives of the modules.

The literature review includes the following seven categories:

- Climate Change Impacts, compiled by Shauna Casey
- Needs Assessment, compiled by Dawn Nelson
- Vulnerabilities and Risks, compiled by Cybelle Shattuck
- Adaptation, compiled by Cybelle Shattuck
- Scientific Uncertainty and Climate Change Communication, compiled by Sara Katich
- Regional, State and Local Policies, compiled by Rebecca Held
- Tools, compiled by Danielle Forsyth

NEEDS ASSESSMENT

To help guide module development, a needs assessment synthesis was first conducted to identify the target audience and their primary climate adaptation needs. The master's project students collaborated with members of the NOAA Great Lakes Regional Collaboration Team, Great Lakes Sea Grant Network, the National Estuarine Research Reserve System, and the Great Lakes & Saint Lawrence Cities Initiative to conduct a comprehensive front-end evaluation of training and information needs on climate change adaptation for Great Lakes coastal communities. The goal of this needs assessment was to collect sufficient information about the knowledge, skills, interests, attitudes, and abilities of Great Lakes coastal community planners, stormwater managers, natural resource managers, and policy-makers to design effective training that increases their ability to confront and adapt to the impacts of climate change. Specific objectives of the report include identifying and describing the following for the target audience:

- Current state of awareness, knowledge, and skill regarding climate change
- Perceptions and attitudes regarding the issue of climate change and whether and how it is connected to community planning, stormwater, and natural resource management
- Understanding of potential economic impacts
- Views 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

The needs assessment synthesis provides an overview of priority adaptation needs, and then explores in more detail adaptation needs of communities in the areas of infrastructure (relating to port and regional planning, and water infrastructure); ecosystem-based management; coastal planning and management; and hazard resilience and disaster preparedness.

This needs assessment synthesis was the first of two phases supported by the NOAA Sea Grant Climate Engagement Project and the Great Lakes Restoration Initiative. This report (see Appendix 2) contains the results of Phase I, a synthesis of existing knowledge on training and information needs and preliminary data collection, supported by the NOAA Sea Grant Climate Engagement Project.

TOOLS INVENTORY

The tools inventory, which grew out of the tool literature review, is a document that synthesizes tool resources available for Great Lakes communities to adapt to climate change impacts. The full inventory provided foundational materials from which to draw tools and resources for inclusion in Module 3. An extensive search produced a wide array of potential climate adaptation tools, which were then analyzed for their applicability to the Great Lakes region and to this project. In order to gather data for the tool literature review, David Hart, Wisconsin Sea Grant; Heather Stirrat and Stephanie Fauver, NOAA; Margaret Mahooney and Steve Ackerman, Cooperative Institute for Meteorological Satellite Studies; and Martin Jaffee, University of Illinois, Chicago Great Cities team gave suggestions on where to find tools or specific tools to look for, and then we recorded these tools and used those websites to find additional tools and website sources. Once this data was collected and compiled into a tool literature document, the tool inventory began. Later, as new tools were discovered throughout the project, they were added to the tool literature review.

In order to evaluate the tools from the literature review, we divided the tools among the team members to review and categorize into various criteria. The criteria that were used were partially based on the Ecosystem Based Management tool inventory,[4] and were also based on whether the team felt the specific criteria would be important to note for this project, such as cost. The criteria used in the tool inventory were as follows: Tool Name; Tool Type (Software, Non-software, Method); Provider; Website/Sources; Sector; Cost; System Requirements; Strengths and Limitations; Technical Expertise Needed (Basic Computer Skills, Some GIS, Intermediate GIS, Extensive GIS); Geography; Keywords; Format; Date; Projects that Have Used the Tool; Recommendation as a "Priority" Tool for Team to Focus on; and Other Information of Interest.

From this evaluation of tool criteria, we were able to identify tools that would be most useful for Module 3. Criteria were based on the above categories and the team members' individual evaluation of each tool. Tools that did not apply to the Great Lakes area were eliminated from the final list. Tools were removed if they did not work when we went to the site, and tools were also eliminated based on whether they applied to adaptation planning. Cost and sector did not necessarily dictate whether a tool stayed on the list, but tools that were free and from public or nonprofit organizations were highlighted. The selection process included a preference for recently developed tools, although older tools might be included if they were particularly valuable, and tools with varying technical requirements were also retained.

Tools that were included in the rough draft of the tool inventory report were crosschecked with the Ecosystem Based Management's reference sheet that

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[4] Ecosystem Based Management Tools. (2010). *Ecosystem Based Management Tool Inventory*.

highlighted key tools for climate change adaptation.[5] A preliminary draft was drawn up that categorized tools into different tool types. The tool inventory report then underwent multiple updates at each review meeting, with one major change being that a state climatology section was added so that users could be directed to state climatologists if they had questions, and to provide them with assistance in finding data or selecting tools.

The tool inventory report (Appendix 3) lists the results of the tool inventory analysis, and is also used as the Great Lakes Climate Adaptation Tool Handout for Module 3. Tools in the report are divided into the same categories as the tools in Module 3: Community Outreach Tools; Education, Training, and Support; Data Websites; Analysis Tools and Systems; Other Informational Websites; and Visualization Tools.

[5] Carr, Sarah. (2010). *Tools for Predicting and Mitigating Coastal Hazard and Climate Change Impacts.* Ecosystem Based Management Tools.

PILOT

The *Climate Ready Great Lakes* project is a building block that will inform and be applied to the larger GLRI Climate Adaptation Project that is also underway. It supports identification of climate change needs for education, outreach, communication and capacity building among Great Lakes communities. A deliverable for the *Climate Ready Great Lakes* project was to provide one training workshop for Great Lakes Sea Grant staff to prepare them to deliver the modules to coastal community officials in their states and regions.

We initially conceived of the pilot in three phases: 1) we would present our objectives, outlines and key slides at the Great Lakes Regional Collaboration team's semi-annual meeting in Alpena, Michigan, in early August for evaluation and feedback; 2) we would then offer a "train-the-trainer" workshop at the Sea Grant network meeting in October, 2010; and 3) we would observe at least one Sea Grant trainer delivering the training in a community in late fall 2010. We identified the communities of Spring Lake, Michigan, and Bayfield, Wisconsin, as pilot communities.

This plan was revised because the Sea Grant Network meeting, scheduled for August, was cancelled. We considered several alternatives to this training. First, we considered targeting only agents from the Spring Lake and Bayfield pilot communities. This approach was rejected, however, because it would only give us feedback from two extension agents, and because Spring Lake had been identified by the Needs Assessment team as a possible community for focus groups as part of Phase II of the Needs Assessment, and we did not want to over-tax those locations. We also considered hosting a webinar for Sea Grant staff in order to get feedback from more extension agents while including Sea Grant agents from Michigan (and nearby areas) in the live audience. However, we believed it would be a more enriching and engaged discussion with live audience members, and they would provide the most useful feedback. Therefore, we offered funding for travel for one Sea Grant agent from Michigan, Wisconsin, Minnesota, Ohio, northwestern Pennsylvania, and western New York, with the understanding that more agents would be welcome if they could finance the trip themselves. We then conducted a pilot training at the NOAA offices in Ann Arbor, Michigan in November 2010. This extended our timeline, and precluded the possibility that students would be involved in the delivery of the training to pilot communities since we had scheduled to complete our work for the client by December 2010.

The final pilot phases consisted of: 1) presenting at the Great Lakes Regional Collaboration team's semi-annual meeting in Alpena, Michigan (August 2010); 2) hosting a "train-the-trainer" for Sea Grant Extension agents from six states (November 2010); and 3) presenting an overview of our project at NOAA headquarters in Silver Springs, MD. (February 2011). Each phase allowed us to gather important feedback to improve the modules, taking into consideration concerns of the Regional Collaboration Team and Sea Grant staff who had conceived of the project, the needs and interests of Sea Grant education staff who would deliver the trainings, and the broader perspective and expertise of NOAA staff.

RESULTS

LITERATURE REVIEW

The Literature Review was conducted in February and March 2010. We reviewed materials in the following categories supplied by the NOAA and Sea Grant team: Adaptation; Climate Change Impacts; Scientific Uncertainty and Climate Change Communication; Needs Assessment; Tools; Regional, State and Local Policies; Vulnerability and Risk Assessment. The collected literature was compiled into a single annotated bibliography in April 2010. (See Appendix 1)

The bibliography includes a mix of gray literature and peer-reviewed materials. The quality of this bibliography has been evaluated in two ways. The first concerned the completeness and relevance of the materials included. This Literature Review pulled together sources known to various NOAA and Sea Grant agents, and added more materials from journals and websites located through the University of Michigan library's searchable databases. Experts from within NOAA, Sea Grant, and other advising organizations such as The Nature Conservancy reviewed the bibliography. We do not claim that the document is exhaustive but, according to our reviewers, it contains over 300 citations that are a representative sample of materials on the topic of adaptation to climate change in the Great Lakes area.

The second means of evaluation concerned how well the collected materials supported the *Climate Ready Great Lakes* project. The bibliography successfully provided foundational knowledge that was used to conceptualize the education modules and determine the data to be incorporated into them. In the course of developing the education modules, the bibliography had to be revised to include additional materials necessary for the project and new sources of information that became available. As a result, the current version, in March 2011, is even more complete than the original Literature Review that was approved in March 2010.

NEEDS ASSESSMENT

The Needs Assessment began with an assessment of training and information needs and preliminary data collection. This resulted in a synthesis report (see Appendix 2), completed in July 2010 and published by NOAA in March 2011.[6] The report helped define the audience for the project and ensure that materials being developed were in sync with community needs.

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[6] D. Nelson, H. Elmer, R. Held, D. Forsythe, and S. Casey. (2010) Laurentian Great lakes Basin climate Change Adaptation, NOAA Technical Memorandum GLERL-153. www.glerl.noaa.gov/pubs/techrept.html

TOOLS INVENTORY

We developed an inventory of existing tools related to climate change in coastal communities. This was completed in June 2010. Expert reviewers with knowledge of climate change issues ascertained its completeness.

The inventory was then analyzed for its relevance to the Great Lakes area and usefulness for community education modules. The list was fine tuned to concentrate on the most useful tools. The list of tools was organized into the following categories: Analysis Tools and Systems, Forecast Models, Visualization Tools, Community Outreach Tools, Training, Data Websites, Resources for Finding Additional Tools, and Other Informational Websites. Later, as the needs of Module 3 evolved, the Tools list was revised into new categories: Community Outreach Tools; Education, Training and Support Tools; Data Websites; Analysis Tools and Systems; Other Informational Websites; and Visualization Tools. As the three modules evolved, some tools that were not part of the initial inventory were added. These related to topics like tree canopy and stream buffers--ideas not specific to coastal areas, but valuable for adaptation in most communities. The final Tools Inventory is included in Appendix 3.

THE EDUCATIONAL MODULES

The overall objectives and format for the project were pre-determined by NOAA and Sea Grant in their application for the mini-grant. The client requested PowerPoint presentations with supplemental background materials.

The objectives and content in the modules developed based on initial recommendations from professional advisors and our subsequent research. The modules are organized to start with broad regional climate knowledge then guide participants toward awareness of local implications of that knowledge and familiarity with strategies and tools for developing a climate adaptation plan. Thus, Module 1 of the presentation presents predicted impacts of climate change, narrowing the focus from global patterns to describe implications for the Great Lakes region. Module 2 describes a planning process to help communities assess local vulnerabilities then moves on to an overview of effective strategies for addressing impacts. Finally, Module 3 describes tools and resources used to research and select the best strategies for a locally appropriate adaptation plan.

An evaluation of the three modules took place in November 2010. The students presented a dry run of all three modules and gathered feedback from Rochelle Sturtevant, Jennifer Day, and Lynne Chaimowitz. This allowed for revision prior to the Train the Trainers workshop on Nov 10-11, 2010.

During the Train the Trainers workshop, the modules were presented to Sea Grant extension agents from the Great Lakes region. A survey of the agents participating in the workshop indicated that all were "very likely" or "somewhat likely" to use Modules 1 and 2, although most indicated they would make modifications to tailor the presentations to their specific needs. For Module 2, some agents indicated they would only use parts of the materials that were most relevant depending on their audience. Six people said they were "very likely" or "somewhat likely" to use Module 3; here again agents suggested they might use selected parts of the module rather than the entire presentation, as appropriate to the community context. All of the agents indicated confidence in their ability to use Module 1. Confidence about use of Module 2 varied from very confident (1 person) to somewhat confident (4 people) and one person who only felt a 50/50 sense of confidence. Similarly, two people were very confident in their ability to use Module 3, three were somewhat confident, one was intermediate (50/50) and one was not confident.

The modules are now posted on the NOAA in the Great lakes website at url http://www.regions.noaa.gov/great_lakes/climate_ready.html. They will soon be available on a Sea Grant website.

MODULE 1: PROJECTED IMPACTS OF CLIMATE CHANGE

INTRODUCTION

This module was designed to help local decision-makers understand the potential range of variability in climate change predictions, and how these changes are likely to impact local communities. It provides an introduction to climate science, an overview of global climate change impacts, and then scales the discussion of climate change down to the regional level, discussing projected climate change impacts for the Great Lakes region.

Module 1 has two goals:

1. Participants will know regional climate impacts.
2. Participants will know why they need and should consider including climate change adaptation in planning.

Module 1 has three objectives. By the end of the workshop/presentation, participants will be able to:

1. Understand that climate change has a scientific basis and is a relevant issue for planning professionals.
2. Understand that there will be similarities and differences between climate change impacts observed at the regional (Great Lakes) and global scales.
3. Identify at least one climate change impact specific to the Great Lakes region that will affect issues within their professions.

MODULE DEVELOPMENT

Climate Literacy: The Essential Principles of Climate Sciences, *A Guide for Individuals and Communities*,[7] provided the foundation for determining the objectives and content to address objectives one and two. This framework was developed by Federal agency scientists (including NOAA), educators, and representatives from non-governmental and other agencies and summarized the most important concepts and principles in climate science. In addition, to develop content to address objectives two and three, we conducted a literature review of climate change impacts on: Great Lakes acidification, ecosystem changes, economics, food security, freshwater systems and hydrology, human health, ice, lake levels, tourism, and weather. Two other key documents, *Global Climate Change Impacts in the United States: Midwest Report*,[8] and *Communicating Climate Change in the Great Lakes Engagement Project- Final Report*[9] from the Great Lakes Regional Collaboration Team, presented in 2010 to NOAA staff, also

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[7] *Climate Literacy: The Essential Principles of Climate Sciences: A guide for individuals and communities*. U.S. Global Change Research Program. Washington, D.C., 2009.

[8] *Global Climate Change impacts in the United States*, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

[9] *Communicating Climate Change in the Great Lakes Engagement Project***-** *Final Report*. Great Lakes Regional Collaboration Team, 2010.

provided part of the basis for the content of the Module 1 outline and slides. This first phase of Module 1 development lasted from May – August 2010.

In August 2010 we presented our objectives, outline, and slide drafts at the Great Lakes Regional Collaboration Team's semi-annual meeting, held in Alpena, Michigan, which served as the first phase in our evaluation process. The key issues highlighted in the evaluation were: 1) how the module should present the idea of "downscaling" to a lay-audience, 2) how to effectively address the perceived issue of scientific uncertainty, 3) how the module should present lake level variability, given a well-established body of peer-reviewed literature indicating that lake levels would drop are at odds with an emerging but less peer-reviewed body of research indicating that they are likely to rise, and 4) the need to explicitly include language indicating that our knowledge will change. From August – November 2010 we continued developing content for Module 1 slides and narration notes, incorporating feedback from the August evaluations. To address issues identified in the evaluation, we provided slides on downscaling that Sea Grant Agents can use to create a handout for a lay-audience. We also added language to the slides indicating that climate change science is changing. Finally, in our discussion of lake level variability we emphasized that while there is uncertainty whether overall lake levels will go up or down, there is great certainty that lake levels will continue to fluctuate, as they have historically.

On November 10-11, 2010 we presented the modules to six Sea Grant Extension agents from the Great Lakes region who will be delivering the modules in their communities. Key issues they identified were: 1) agents wanted local examples of observed climate change impacts to make them more relevant to local audiences, and 2) summary slides would be useful for each major section of the presentation in the Great Lakes climate impacts section. We added summary slides to our final revision; however, because this training has the potential to be offered to a large number of communities in the Great Lakes region, we could not justify the additional time and research required to add local case studies at this stage in module development. In lieu of this, we decided that the modules and resources would be made available on Sea Grant website, and case studies can be added by Extension agents over time. In this way, the Sea Grant agents will improve ownership over the program, and can tailor their presentations to suit the needs and interests of the communities where are presenting.

FINAL PRODUCT

Module 1 has undergone edits by NOAA professional editors and a final review by Module 1 student team members. Part One of the Module provides information on climate science, weather and climate, climate variability, observed and projected global climate changes, climate models, and climate change impacts in the Great Lakes region. Part 2 discusses the implications of climate change on Great Lakes communities, providing information on hydrologic impacts (including lake levels, melting ice, and severe weather); ecological impacts (including habitat and ecosystem changes); and impacts on human health and the economy (including air and water quality, disease, agriculture, shipping, tourism and energy). This module (provided in Appendix 4 and digitally on NOAA Great Lakes' website; available in the future on Sea Grant's website) will continue to be adapted by NOAA staff and Sea Grant agents to keep the presentation current with the latest peer-reviewed research on climate change and climate impacts and to meet the specific needs of different communities.

MODULE 2: DEVELOPING AN ADAPTATION PLAN

INTRODUCTION

Module 2 addresses the question, "What is an adaptation plan?" It is designed to help people take general predictions about how climate change will affect the Great Lakes region and start thinking about what that means for their community. This then lays the foundation for exploring adaptation strategies that are tailored to needs of the community.

Module 2 has two goals:

1. To help people understand what an adaptation plan is.
2. To explain some strategies for adaptation that can be incorporated into an adaptation plan. These strategies, or measures, are organized around the impacts climate change is predicted to have on the Great Lakes region.

Module 2 has three objectives. By the end of the workshop, participants will be able to:

1. Understand the steps of an adaptation plan.
2. Understand the value of collaboration in adaptation planning.
3. Demonstrate the ability to apply adaptation strategies to a specific climate change impact.

MODULE DEVELOPMENT

Research for Module 2 began with a review of literature on vulnerability assessments and adaptation. The latter focused on eight topics that were suggested by Marty Jaffe[10] and Brian Miller[11] as being necessary for climate adaptation: stormwater management, floods, drought, ecosystem resiliency, shoreline infrastructure, urban heat islands, conducting vulnerability assessments, and benchmarking and administration. The subject of adaptation itself was addressed through materials on climate adaptation efforts at national, state, and local levels. Additional bibliographies on vulnerabilities and risks, scientific uncertainty and climate change communication, and regional, state, and local policies, contributed to the information used in developing the module.

In order to meet the dual goals of the module, it was divided into two sections, one for planning and one for strategies. Materials were developed over the summer and, in August 2010, we gave a preliminary presentation on the objectives, outline, and format of the module slides at the Great Lakes Regional Collaboration Team's semi-annual meeting, held in Alpena, Michigan. Evaluative feedback focused on the following issues: 1) The language used to describe planning processes should be synchronized with the new Planning Guide for

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[10] Martin Jaffe, Associate Professor, Dept of Urban Planning and Policy, University of Illinois at Chicago

[11] Brian K. Miller, Director of Illinois-Indiana Sea Grant

coastal managers[12] that NOAA was about to publish; 2) Summaries of climate impacts from Module 1 should be added to the beginning of each topic in the Part Two strategy section to remind participants of what problems the strategies are solving; 3) More examples of cases from communities smaller than Chicago would make the information more relevant to the intended audience; 4) Opportunities as well as risks should be stressed when doing vulnerability assessments to increase motivation for implementing adaptation planning; 5) The policy materials should be combined into a single section in order to streamline the presentation; and 6) Cost-benefit analyses of strategies should be added since costs are often the biggest perceived obstacle to climate adaptation. We made most of these changes. It was not practical to include cost-benefit analyses of every adaptation strategy due to a lack of information and the variation among communities, but we did add a section on the value of cost-benefit analysis as part of the strategy selection process and included a case study example. We added more emphasis on the possibility of opportunities to the vulnerability assessment slides in the planning section, but were not able to find good case studies to illustrate beneficial potential. Feedback from a dry run of the complete module in November led to the addition of slides with "take-away" summaries at the end of each strategy topic section in Part Two.

After incorporating these changes, Module 2 reached its current format. Part One describes the steps in a climate adaptation planning process. The planning framework was derived from *Adapting to Climate Change: A Planning Guide for State Coastal Managers* (NOAA 2010). This was combined with information from the process used to develop Chicago's Climate Action Plan[13] because that city has progressed farther in adaptation planning than any other community in the Great Lakes basin. Sea Grant agents stressed their need for stories that could make climate change and adaptation planning real and accessible to community members. The module used Chicago and other case studies to illustrate both planning processes and adaptation strategies.

Part Two of the module described some of the strategies that can be incorporated into an adaptation plan to address topics related to the predicted impacts of climate change for the Great Lakes region. The climate strategy sections are: Water Management, with subtopics on Stormwater, Green Infrastructure, and Flood prevention; Drought, with subtopics on Crops, Shipping, Habitat, and Energy; Infrastructure, with subtopics on Buildings, Roads, Shipping, Shoreline, and Energy; Ecosystems, with subtopics on Plants (Crops and Trees), Fish, Animals, and Water Quality; Urban Heat, with subtopics on Energy, Infrastructure, and Health. A final section of Part Two describes financial and regulatory incentives that can be used to promote and support adaptation planning.

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[12] NOAA (2010) *Adapting to Climate Change: A Planning Guide for State Coastal Managers*

[13] Chicago Climate Action Plan; www.chicagoclimateaction.org/

Incentives to motivate participants were also woven into themes that recur throughout Module 2. These include stress on the value of win-win and no-regret options, the savings to be derived from anticipating climate impacts and planning ahead instead of reacting afterwards, as well as the importance of incorporating climate planning into existing community planning processes to take advantage of resources and improve implementation. Hopefully these themes enhance the likelihood that municipalities perceive adaptation planning as feasible and improve chances for implementation.

Module 2 includes supplemental materials to be used in workshops. Two worksheets were developed to help participants apply presentation information to their own local communities. These are to be handed out at the end of each section. A set of one-page case studies provides background for some of the examples used in the presentation in order to help presenters tell the stories. Handouts on Planning Processes, Potential Planning Team Members, and Case Studies related to the topics covered will help participants recall information from the workshop. Three charts provide resources listing Stormwater Control Measures, Potential Federal Funding Sources and Federal Laws relevant to climate change on the coast.

FINAL PRODUCT

Module 2 was presented to Sea Grant extension agents on Nov 10-11, for a Train-the-Trainers workshop at the Great Lakes Environmental Research Lab in Ann Arbor. All participants said they would find use for the Part Two materials, although they would probably modify the presentation by adding case studies of their own when they needed examples that would be particularly relevant to a specific community. Some agents were less certain about whether the Adaptation Plan overview in Part One would be useful since they might be talking to an audience of planners who already knew much of that information. The agents were pleased that the flexible format of the module would allow them to pick and choose among the sections so they could tailor the presentation as needed. Thus, the information, organization, and format of Module 2 seem to be appropriate for the client.

The PowerPoint presentation has undergone two final forms of editing since that presentation. Revision based on feedback from Sea Grant assures that the information is organized in a way that meets their needs and that its contents are in accord with current knowledge of best practices. In January 2011, NOAA had the PowerPoint slides professionally edited; this improved the format of the slides. We assume that these materials (See Appendix 5) will be continually updated and improved in response to the experiences of agents using them in the field.

MODULE 3: CLIMATE CHANGE ADAPTATION TOOLS AVAILABLE TO GREAT LAKES COMMUNITIES

INTRODUCTION

The third module in the *Climate Ready Great Lakes* series was made to introduce participants to a wide range of tools useful for adaptation planning in the Great Lakes. Because the module was targeted towards Great Lakes communities, all of the highlighted tools were either made for the Great Lakes region specifically or could be modified to fit the region. Featured tools were mostly related to adaptation to climate change impacts, but were also selected to help decision makers assess vulnerability to climate change. The tools were chosen so that they could be utilized by a wide range of users with different technical backgrounds, ranging from Geographical Information Systems (GIS) experience to basic computer skills. Given this wide range of tools, Module 3 was made to help participants with various levels of tool experience learn to find and use tools and resources to help them develop an adaption plan to prepare for predicted climate change impacts in the Great Lakes region.

Module 3 had two goals. They were that participants would:

1. Know what tools and resources are available for adaptation planning.
2. Have some ability to select tools and use them effectively.

Module 3 had three objectives. They were that by the end of the training, participants would:

1. Know what tools and resources were available for adaptation planning.
2. Know how to access tools and resources.
3. Demonstrate the ability to select a tool that fit their goals and targeted climate impacts.

MODULE DEVELOPMENT

Module 3 built off the previous work that was done for the tool inventory, and started development in July 2010, as we finished drafting the tool inventory. At first, we considered focusing on one or two tools to train participants in, but then decided that a broad overview would be more useful for a number of reasons. First, sufficient introductory training was already available for many of the tools. Second, none of the working group members specialized in any of the tools, and could not provide expert training. Finally, there was also the question of whether or not this type of format would be useful for the Sea Grant extension agents. Therefore, the working group decided to change the module to its final format, which was an overview of tools and tool categories constructed to help participants view the kinds of tools available for adaptation planning.

By August 2010, we had constructed a rough draft of the module that was reviewed at the group meeting in Alpena, and from this meeting major changes occurred in the module format. There were two additional tool categories in the original rough draft—48-Hour Forecasting Tools and Forecast models—that were removed from the module after the review. The 48-Hour Forecasting Tools category was removed because it was seen as more related to weather and the Forecasting Tools were either moved to other categories or removed because the tools were too broad, were still under development, or did not fit the category well. Another major change that took place was that the reviewers felt that there was not enough context for tool use, and that there was not enough emphasis on utilizing technical and human resources. In response to this, and in order to better meet the second goal of the module, an introductory Part One portion of the module was added that reviewed how to properly use and select tools and how to find assistance.

After this meeting, we decided to add an introduction for each category that explained how tool categories and tools could be applied to adaptation planning so that more connections to adaptation planning could be made. We also strongly felt that adding case studies would help to illustrate tool use and applications to adaptation planning, so we inserted case studies wherever this information was available. Case studies were highlighted for BASINS 4.0[14], the Great Lakes Information Network (GLIN)[15], Habitat Priority Planner[16], and CanVis[17]. We also decided to leave in a smaller CanVis[18] training that showed briefly how the software could be used to visualize windfarms on a Great Lakes coastline.

A few more changes were made after a dry run of the module in October and the Train the Trainers meeting. After the dry run, the tool categories were reordered so that they mirrored the adaptation planning process in Module 2. This meant that tools that would be useful earlier in the process appeared first in the module, and tools that would be used later in the adaptation planning process were placed later in the module. Additionally, the Training Tools and Resources for Finding Additional Tools categories were combined into the Education, Training, and Support Tools category because of substantial overlap. Finally, the team decided to keep the CanVis[19] training example in the module because the Sea Grant extension agents felt that module participants would be interested in an illustration of how CanVis[20] could be used by a beginner.

FINAL PRODUCT

Module 3 underwent edits by NOAA professional editors and a final review. The Module 3 final draft had two major sections (Appendix 6). Part One went over

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[14] Environmental Protection Agency. (2007). *BASINS (Better Assessment Science Integrating point and Non-point Sources) 4.0*.

[15] Great Lakes Information Network. *Great Lakes Information Network (GLIN) Maps and GIS*.

[16] NOAA Coastal Services Center. *Habitat Priority Planner.*

[17] NOAA Coastal Services Center. *CanVis.*

[18] *Ibid*

[19] *Ibid*

[20] *Ibid*

how to properly use tools and started by going over tool definition and how tools could be useful for adaptation planning. Then it highlighted the importance of goal definition and identifying climate impacts in order to choose a tool. This section also was constructed to help participants consider resources, in order to determine if they have the various resources necessary to utilize specific tools. This section then discussed effective tool use by starting with learning tool mechanics, moving to understanding tool and data origin, and ending with utilizing technical assistance and finding data for a project.

Part Two highlighted the major tool categories relevant to adaptation planning and went over examples from each category. The final tool categories of Part Two were as follows: Community Outreach Tools; Education, Training, and Support; Data Websites; Analysis Tools and Systems; Other Informational Websites; and Visualization Tools. This section was organized so that for each tool category, there were slides that introduced the category, explained how the category in general could be applied to adaptation planning, provided examples of a tool and case studies, and then listed the other tools in the category. This part was meant as an introduction to the various types of tools that are available, and as such did not highlight every available tool; rather it showed the uses for tools in each category and led participants to finding tools that might be right for their adaptation plan.

Module 3 also had several worksheets that were meant to be used in conjunction with the module, and were developed to meet module objectives. The first was called the Great Lakes Climate Adaptation Tool Handout, which also doubled as the Tool Inventory final product (Appendix 6). This sheet described each tool category and all of the tools within the category, and gave a short description, listed keywords, contacts, costs, training and time requirements, and other requirements associated with the tool. This worksheet helped to meet objectives 1 and 2, as it contained a list of tools relevant to adaptation planning that were as up-to-date and expansive as possible. It also listed ways to find the relevant contacts. The second worksheet that was created was the Tool Applications Spreadsheet (Appendix 6). This handout helped to meet objective 3 because it illustrated how to match tools with specific climate change impacts. If participants knew which climate impact they wanted to target, they could use this sheet to quickly gauge which tools may be right for their adaptation plan. Finally, a third worksheet called the Choosing a Tool Handout, was developed to help participants synthesize the information from the module (Appendix 6). The interactive worksheet was meant to be used after the module was presented and to help participants think about which tools to use for their project. The handout was made to help participants define a goal, utilize the Tool Applications Spreadsheet to find a tool that fits a specific impact, and finally think about what kinds of resources the tool would require.

In order to meet its goals and objectives, Module 3 has undergone significant transformation over time and a number of supporting documents have been created to enhance the module. Handouts were designed to help participants synthesize data from the presentation and to further research tools in order to determine which tools may be right for their adaptation plan. The structure of the module itself helped to ensure that participants would not only learn about available tools, but learn how they could effectively use tools or find assistance with utilizing a tool. Since this module highlighted new tools and resources, it was expected to be revised more frequently than the other modules and will need updating as new tools become available and as websites and other resources change.

Appendix 1

Climate Ready Great Lakes

An Annotated Bibliography
University of Michigan
School of Natural Resources and Environment
GLC4 Master's Project
Spring 2010

GLC4 TEAM
This bibliography was produced by the University of Michigan
Master of Science student team
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Contributors: David B. MacNeill, John Cawood

Project Objectives

The Literature presented here will inform the final training module set with these specific goals:
• Summarize recent climate change research results and long-term forecasts for climate change impacts;
• Prepare leaders to identify and consider management responses necessary to respond to forecasted changes, and
• Familiarize leaders with decision tools and science based resources needed to make coastal development,
resource protection, and infrastructure decisions today that will shape their communities coastline and keep communities sustainable for the next 50-100 years.

Module Development

Module 1: Predicted Impacts of Climate Change:
Presents an overview of predicted climate change impacts in the Great Lakes including predicted changes in temperature, storm events, water levels, and more

Module 2: Overview of an Adaptation Plan:
Outlines the basic principles of developing a local climate change adaptation plan, the content needed in a plan, as well as examples and case studies of how communities are planning for climate change.

Module 3: Tools and Information:
Highlights tools that have been developed by NOAA, Sea Grant and other federal agencies to assist local communities with assessing climate change vulnerability and adaptation planning implementation.

TABLE OF CONTENTS: ANNOTATED BIBLIOGRAPHY

Climate Change Impacts

Acidification

Waples J., Eadie, B, Klump, J., Squires, M., Cotner, J., McKinley, G. (2008). "The Laurentian Great Lakes." In: North American Continental Margins Working Group for the U.S. Carbon Cycle Scientific Steering Group and Interagency Working Group. U.S. Carbon Cycle Science Program, Washington, DC, 110 pp.

In this report, the authors state that the northern region of the Great Lakes is different from the southern region of the Great Lakes in terms of carbon availability. The Canadian Shield is a large granite slab to the north of Lake Superior, which is covered with just a thin layer of acidic soils. The rest of the Great Lakes are surrounded with much deeper soils, composed of sand, silt, and most importantly (for our purposes) carbonate. Lake Superior is cold and oligotrophic, while the other lakes are more eutrophic, receiving more carbon from the surrounding soils in their drainage basin. Also, mussels in Lake Erie have caused the calcium levels of the lake to drop noticeably. In the end, "the consequences [of climate change] for carbon cycling are complex and not yet fully modeled. Less ice cover, earlier thermal stratification, warmer and thicker upper mixed layers and generally faster rates for carbon related processes all need to be evaluated." This is from a subject specific report, not a peer-reviewed journal.

Link (full text): http://www.carboncyclescience.gov/documents/nacm-2005.pdf

Ecosystems

Karl, T., Melillo, J., and Peterson, T. Editors. (2009). *Global Climate Change Impacts in the United States*. U.S. Global Change Research Program. Cambridge University Press

This report predicts that Midwest wetlands will become reduced due to an increased duration between precipitation events in the summer. They also estimate that plant habitats will shift to the north at a relatively fast pace. "By the end of the century plants now associated with the Southeast are likely to be established throughout the Midwest."

Report Link: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts/midwest

Myers, P., et al. (2009). "Climate-induced changes in the small mammal communities of the northern Great Lakes Region." 15(6): *Global Change Biology* 1434-1454.

This article discusses the results of a recent study tracking small mammals in Michigan. The authors found that animals in southern Michigan have seen their ranges shift into northern Michigan, displacing animals in those communities. The authors suggest that these migrations are aligned with climate predictions. Link:

http://www3.interscience.wiley.com/journal/121634609/abstract \
News link: http://www.sciencedaily.com/releases/2009/05/090512193300.htm

Thomson, A. M., C. L. Riddell, et al. (2009). "Boreal forest provenance tests used to predict optimal growth and response to climate change: 2. Black spruce." *Canadian Journal of Forest Research* 39(1): 143-153.

This study discusses current regional variation in the growth patterns of black spruce trees in Ontario, predicting climate change impact on communities in each region. The authors point out that large-scale temperature increases are expected to have a detrimental effect on the height growth of spruce populations in central and southern Ontario. Link: http://www.ingentaconnect.com/content/nrc/cjfr/2008/00000039/00000001/art00014%3Bjsessionid=gxc9t7qfu7eb.alexandra

Sharma, S., D. A. Jackson, et al. (2007). "Will northern fish populations be in hot water because of climate change?" *Global Change Biology* 13(10): 2052-2064.

In this article, the authors model the shift of the small mouth bass' habitat range according to IPCC climate models for the next century. They predict that the warm-water fish like the smallmouth bass will experience a habitat shift towards lakes in northern Canada as temperature optimums are achieved. Link: http://www3.interscience.wiley.com/journal/120825859/abstract

Doka, S., C. Bakelaar, et al. (2006). Coastal wetland fish community assessment of climate change in the lower Great Lakes. Ottawa, ON (Canada), EC.

This paper described the known and unknown impacts of climate change on coastal wetland fish in the lower Great Lakes, noting that decreased lake levels, changes in vegetation, increased dry areas, and species invasions would increase the vulnerability of such fishes. The authors noted that hydrological changes, as they affect fish and fish habitat, have not been well studied. Report Link: http://www.environment.uwaterloo.ca/research/aird/wetlands/index_files/page0012.htm

Goldblum, D. and L. S. Rigg (2005). "Tree growth response to climate change at the deciduous-boreal forest ecotone, Ontario, Canada." *Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere* 35(11): 2709-2718.

This article suggests that the Sugar Maple tree will become more prominent at its current northern limit in Ontario, according to future climate modeling. In contrast, coniferous trees like the white spruce or balsam fir are not expected to benefit from rising temperatures. Link: http://bellwether.metapress.com/content/86t63743r8864431/

Walker, K. V., M. B. Davis, et al. (2002). "Climate change and shifts in potential tree species range limits in the Great Lakes Region." *Journal of Great Lakes Research* 28(4): 555-567.

This study utilized biological and climate models to establish growth patterns of ten tree species in the Great Lakes Region through the STASH model. The authors noted that rising temperatures will force five important tree species into a northern retreat (quaking aspen, Yellow birch, red pine, white pine, and jack pine) while several others, such as the black cherry may take advantage of future potential habitat to the west.
Link (full text):
http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B984D-4VJ59FT-6&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1003428366&_rerunOrigin=scholar.google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=eb8afa04feafc1add8ac80d8b29a0d32

Economics

Broecker, W. S., and R. Kunzig, 2008: *Fixing Climate: What Past Climate Changes Reveal About the Current Threat—and How to Counter It*. Hill and Wang, 253 pp. (p.164-165).

Food Security

Prioritizing Climate Change Adaptation Needs for Food Security in 2030. Lobell et al., *Science* 319, 607 (2008)

Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change. Searchinger et al., *Science* 319, 1238 (2008).

Freshwater

Angel, J. and Kunkel, K. (2009). "The response of Great Lakes water levels to future climate scenarios with an emphasis on Lake Michigan." *Journal of Great Lakes Research*, in review.

The researchers in this study attempted to determine the impacts of climate change on temperature, precipitation, and water levels of the Great Lakes, using numerous general circulation models and a lake level model developed by the Great Lakes Environmental Research Lab (Croley 2006). They completed over 500 model runs, which resulted in a substantially wide range of results. 90% of temperatures results for 2090 indicated increases between 2.5 and 12 degrees when compared to the average temperatures from 1971-2000. Under the "business as usual" scenario, about 95% of the results indicated at least in a 7 degree increase. In terms of precipitation, 90% of the model results for 2090 were between a decrease of three inches and an increase of eight inches. Their lake level results also exhibited a large range; on lake Michigan 90% of the results for

2080 were between an increase of 2.89 feet and a decrease of 5.90 feet. They attribute this range to differences in emission scenarios as well as uncertainty in the model simulations.
Project link: http://www.isws.illinois.edu/wsp/climate/ClimateTom_scenarios.asp

Cherkauer, K. and T. Sinha. (2009). Hydrologic impacts of projected future climate change in the Lake Michigan region. *Journal of Great Lakes Research*. In press.

Dobiesz, N. E. and N. P. Lester. (2009). Changes in mid-summer water temperature and clarity across the Great Lakes between 1968 and 2002. *Journal of Great Lakes Research* 35:371-384.

This paper compiled environmental data from government agencies monitoring the middle and lower portions of the Great Lakes basin (lakes Huron, Erie and Ontario) to document changes in aquatic environments between 1968 and 2002.

Han, H., J. D. Allan, and D. Scavia (2009). "Influence of climate and human activities on the relationship between watershed nitrogen input and river export." *Environmental Science & Technology* 43 (1916-1922).

Applies model of riverine N export for 18 Michigan basin watersheds to three scenarios of future land use, including business as usual, greater reliance on organic farming methods, and expanded corn-based ethanol production, and two climate scenarios, including increases in water discharge by 5% and 10%. Results suggest that riverine N export is likely to increase by as much as 24% in response to heavier fertilizer use for expanded corn production and a 10% increase in annual discharge. However, N export by rivers could decrease below present-day export through reduced reliance on commercial fertilizer use.

Kutzbach, J. E., J. W. Williams, et al. (2005). "Simulated 21st century changes in regional water balance of the Great Lakes Region and links to changes in global temperature and poleward moisture transport." *Geophysical Research Letters* 32(17): 5.

This article investigates the transport of moisture from the equator and towards the poles due to climate change. Specifically they researched how this might impact freshwater distribution in the Great Lakes Region. The authors used eight general circulation models under two climate scenarios, which produced results suggesting that the ratio of precipitation to evaporation will increase in the future. This could lead to a rise in lake levels. This conflicts with several other studies forecasting a drop in lake levels over the 21st century, highlighting the uncertainty behind model-based predictions.
Link (full text):
http://www.geography.wisc.edu/faculty/williams/lab/pubs/Kutzbachetal2005GRL.pdf

Lofgren, B. M., F. H. Quinn, et al. (2002). “Evaluation of potential impacts on Great Lakes water resources based on climate scenarios of two GCMs.” *Journal of Great Lakes Research* 28(4): 537-554.

This study produces a range of lake level predictions for 2090 (+.35 m, and -1.38 m on Lake Michigan and Lake Huron), based on two different climate models. The author notes that precipitation and air temperature are driving factors. Another noteworthy finding in this publication is that one model indicated that most of Lake Erie would be almost entirely ice-free through each of its winters by 2090. Link (full text): http://www.glerl.noaa.gov/pubs/fulltext/2002/20020020.pdf

Sellinger, C. E., C. A. Stow, et al. (2008). “Recent water level declines in the Lake Michigan-Huron System.” *Environmental science & technology* 42(2): 367-373.

The authors examined water level data in Lakes Michigan and Huron from 1860 to 2006 in order to determine whether climate change was contributing to the low water levels at the time were. While they found that evaporation rates have increased after a period of decreased evaporation from about 1950 to 1978, there was not enough evidence to be certain that climate change is responsible for the current trend of low water levels, or that the downward trend will continue in the future. Link (full text): http://www.nicholas.duke.edu/people/faculty/reckhow/KHR%20PDF%20publications/Sellinger2007.pdf

Human Health

Patz, J. A., S. J. Vavrus, et al. (2008). "Climate change and waterborne disease risk in the Great Lakes Region of the U.S." *American Journal of Preventive Medicine* 35(5): 451-458.

This article describes a potential impact of more extreme weather events in the Great Lakes Region due to climate change – waterborne illnesses. The authors draw inferences from IPCC models predicting precipitation events 10-40% stronger than today, claiming that sewage overflow events will increase by 50-120% by the end of the century. They foresee negative impacts on drinking water and recreation around the Great Lakes.
Link (full text): http://sage.wisc.edu/pubs/articles/M-Z/patz/patzetalAJPM08.pdf

Baker, K. M., W. W. Kirk, et al. (2005). "Climatic trends and potato late blight risk in the Upper Great Lakes Region." *HortTechnology* 15(3): 510-518.

This article speaks to the climatological trends of the upper Great Lakes region, which has experienced warmer and wetter growing seasons. It discusses the consequences of the agricultural community’s increased risk of potato late blight in the months of July and August, a disease which prospers under these conditions. Should these trends continue the authors suggest that potato late blight will experience growing infestation opportunities.

Link (full text): http://www.potatodiseases.org/pdf/Baker-Kirk-et-al-climatic-trends-HortTech-2005.pdf

Izaurralde, R. C., N. J. Rosenberg, et al. (2003). "Integrated assessment of Hadley Center (HadCM2) climate-change impacts on agricultural productivity and irrigation water supply in the conterminous United States Part II. Regional agricultural production in 2030 and 2095." *Agricultural and Forest Meteorology* 117(1-2): 97-122.

This publication, stemming from a national agricultural assessment via a global climate model, suggests that the Great Lakes region may experience greater corn and soybean-growing potential in 2030 because of climate-induced temperature and moisture variations. In contrast, current corn-growing areas in the Midwest will lose their capacity to cultivate the crop. The paper also evaluates future potential for growing alfalfa.
Link: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V8W-48BC0TR-1&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1003437034&_rerunOrigin=scholar.google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=ed1e401d3d20a3c51db148d5d5ee40bf

Winkler, J. A., J. A. Andresen, et al. (2002). "Possible impacts of projected temperature change on commercial fruit production in the Great Lakes region." *Journal of Great Lakes Research* 28(4): 608-625.

This article suggests that climate change could increase the commercial fruit growing capacity of coastal communities in the Great Lakes region.
Link: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B984D-4VJ59FT-B&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1003436234&_rerunOrigin=scholar.google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=1c3ac826bf7a7b53e3e3a5b0c9f67e98

Ice

Austin, J. A. and S. M. Colman (2007). “Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures; a positive ice-albedo feedback.” *Geophysical Research Letters* 34(6).

This paper states that the surface water temperatures on Lake Superior in the summer increased 2.5 degrees Celsius between 1979 and 2006, more of an increase than the air temperature over the lake. The authors explain that the lake’s ice cover is responsible for the rapid warming - it reflects light energy away from the warm water; when that amount of winter ice cover declines, the water warms faster since the ice is not there to reflect the energy. Link (full text):

http://tomix.homelinux.org/~thomas/eth/8_semester/master_seminar_atmosphere_and_climate_I_ss_2007/unterlagen/papers/augustin_colman__lake_superior.pdf
News Article Link:
http://www.sciencedaily.com/releases/2007/03/070322110147.htm

Isard, S. A., R. J. Schaetzl, et al. (2007). "Soils cool as climate warms in the Great Lakes Region: 1951-2000." *Annals of the Association of American Geographers* 97(3): 467-476.

The authors of this article used data from a fifty year time period to investigate temperature trends across the Great Lakes Region. While they did not report significant air temperature increases, they did report a significant drop in soil temperatures. Their explanation for this trend is the fact that thinner snow packs resulting from less lake effect snow do not insulate heat as well as normal wintertime snow packs in the Great Lakes Region. As a result, soils "release heat to the atmosphere faster, and more completely, thereby cooling to a great extent". Though the authors seem to suggest that the decrease is due to slow climate change causing fewer snowstorms, they acknowledge spatial patterns that they are unable to describe, signifying an uncertainty in the cause of their results. Link: http://www.informaworld.com/smpp/content~db=all~content=a788942718

Lofgren, B. M., F. H. Quinn, et al. (2002). "Evaluation of potential impacts on Great Lakes water resources based on climate scenarios of two GCMs." *Journal of Great Lakes Research* 28(4): 537-554.

This study produces a range of lake level predictions for 2090 (+.35 m, and -1.38 m on Lake Michigan and Lake Huron), based on two different climate models. The author notes that precipitation and air temperature are driving factors. Another noteworthy finding in this publication is that one model indicated that most of Lake Erie would be almost entirely ice-free through each of its winters by 2090. Link:
http://www.glerl.noaa.gov/pubs/fulltext/2002/20020020.pdf

Tourism

Dickenson, J.E, Derek Robbins, Less Lumsdon (2010). " Holiday travel discourses and climate change." *Journal of Transport Geography* 18: 482-489.

Paper explores "slow travel" (alternative to air and car travel where people travel to destinations more slowly over- land and travel less distance), through interviews with slow and non-slow travelers. The analysis explores the discourses used by both slow and non-slow travellers to justify modal choice in relation to climate change. The paper concludes with some recommendations for the development of slow travel as a tourism adaptation strategy for a lower carbon future.

Huntly, Melinda (2009). "Climate Change and Great Lakes Tourism: Recommendations for research, education, and outreach." Ohio State University Sea Grant Extension.

Grey literature examining impacts of climate change on tourism as well as tourism related adaptation and mitigation strategies. Recommends areas for research, education, and outreach. Not published or peer reviewed.

Wietze, L., Richard S. J. Tol (2002). "Impact of Climate on Tourist Demand." *Climate Change* 55: 429-449.

This paper identifies optimal level of temperature for Dutch tourists, at travel destination for different tourists and different tourist activities. Given the optimal temperature preference identified, states that under a scenario of gradual warming, tourists would spend their holidays in different places than they currently do.

Weather

Desai, A. R., J. A. Austin, V. Bennington, and G. A. McKinley. 2009. Stronger winds over a large lake in response to weakening air-to-lake temperature gradient. *Nature Geosciences*:http://dx.doi.org/10.1038/ngeo1693.

Patz, J. A., S. J. Vavrus, et al. (2008). "Climate change and waterborne disease risk in the Great Lakes Region of the U.S." *American Journal of Preventive Medicine* 35(5): 451-458.

This article describes a potential impact of more extreme weather events in the Great Lakes Region due to climate change – waterborne illnesses. The authors draw inferences from IPCC models predicting precipitation events 10-40% stronger than today, claiming that sewage overflow events will increase by 50-120% by the end of the century. They foresee negative impacts on drinking water and recreation around the Great Lakes.
Link (full text): http://www.sage.wisc.edu/pubs/articles/M-Z/patz/patzetalAJPM08.pdf

Kunkel, K. E., N. E. Westcott, et al. (2002). "Assessment of potential effects of climate change on heavy lake-effect snowstorms near Lake Erie; The potential impacts of climate change in the Great Lakes Region." *Journal of Great Lakes Research* 28(4): 521-536.

Through an analysis of precipitation patterns over 50 years, these researchers determined that six factors contribute to heavy lake-effect snowstorms. According to their results from two general circulation models, the frequency of these storms in the Lake Erie Snowbelt may decrease due to climate change. They stated that the results were driven by the models' expectations for warmer temperatures that will be out of the range required for lake effect snow events, potentially replacing them with large rain events. Link: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B984D-4VJ59FT-

4&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1003394331&_rerunOrigin=scholar.google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=8e16b914c5ab7743f3cb9b86886438ca

Sousounis, P. J. and E. K. Grover (2002). "Potential Future Weather Patterns over the Great Lakes Region." *Journal of Great Lakes Research* 28(4): 496-520.

The authors of this study compare predictions from two general circulation models to present atmospheric conditions in the Great Lakes Region. These models predict extensive change by the end of the century, including, an increase in the number of and intensity of warm fronts and more annual precipitation from (mostly due to the increase in heavy precipitation events caused by these fronts) as well. They also indicate an increase in the number of very hot days and a decrease in the number of very cold days,. Contractions in the results of the two models exist, and the authors suggest that more sensitive studies using the models are needed. Link: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B984D-4VJ59FT-3&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1003398166&_rerunOrigin=scholar.google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=eaf11358a67a45b9de434552659ad0d7

General Resources

Climate Literacy: The Essential Principles of Climate Sciences: A guide for individuals and communities. U.S. Global Change Research Program. Washington, D.C., 2009.

"Presents information that is deemed important to know and understand about earth's climate, impacts of climate change and approaches to adaptation or mitigation. The guide aims to promote greater climate science literacy by providing an educational framework of principles and concepts." The guide can serve educators and community members who want to communicate climate science to a lay audience.

Global Climate Change Impacts in the United States (2009). Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press

"This report summarizes the science of climate change and the impacts of climate change on the United States now and in the future. Based on results of the U.S. Global Change Research Program, and integrates those results with related research from around the world. Authoritative scientific report with the goals of informing public and private decision making at all levels."

IPCC, 2001: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Soloman, S., D. Qin, M.

Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

"Describes progress in understanding of human and natural drivers of climate change, observed change, climate process and attribution, and estimates of projected future climate change."

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Austin, J.A. and S.M. Colman. (2008). A century of temperature variability in Lake Superior. *Limnol. Oceanogr. 53, 2724–273.* *www.aslo.org/lo/pdf/vol_53/issue_6/2724.pdf*

Austin, J.A. and S.M. Colman. (2007). Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback, *Geophys. Res. Lett., 34, L06604, doi:10.1029/2006GL029021.* *www.agu.org/pubs/crossref/2007/2006GL029021.shtml*

Great Lakes Needs Assessment Ports and Navigation. Final Draft Interim Report (August 18, 2006). Great Lakes Commission and NOAA/ Coastal Services Center. Available at: <http://www.glc.org/regionalneeds/>

Hegerl, G. C., F. W. Zwiers, and P. A. Stott, and V. V. Kharin, 2004: Detectability of anthropogenic changes in temperature and precipitation extremes. J. Climate, 17, 3683–3700.

Preparing for Climate Change: A Guidebook for Local, Regional and State Governments. http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf

Report on Great Lakes Beach Health Research Needs Workshop of November, 4, 2005. Great Lakes Beach Association in cooperation with National Oceanic and Atmospheric Association, United States Environmental Protection Agency, and US Geological Survey

Ricklefs, R. E. (2008). *The Economy of Nature*, 6th Edition. W. H. Freeman and Co.

Savonis, Michael J., Burkett, Virginia R., and Joanne R. Potter. (coordinating authors) March 2008. "Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I." U.S. Climate Change Science Program Synthesis and Assessment Product 4.7: Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research

Shiliang Wu, Loretta J. Mickley, Eric M. Leibensperger, Daniel J. Jacob, David Rind, and David G. Streets, "Effects of 2000–2050 global change on ozone air quality in the United States," JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 113, D06302, doi:10.1029/2007JD008917, 2008.)

Sturtevant, Rochelle. 2004. "Great Lakes Ecological Forecasting Needs Assessment." NOAA Technical Memorandum GLERL-131. Great Lakes Environmental Research Laboratory: Ann Arbor, MI.

Transportation Research Board Special Report 290. 2008. "The Potential Impact of Climate Change on U.S. Transportation." Transportation Research Board: Washington, DC

Needs Assessments

Interagency Climate Change Adaptation Task Force March 16, 2010. Progress Report of the Interagency Climate Change Adaptation Task Force. Available at: http://www.whitehouse.gov/sites/default/files/microsites/ceq/20100315-interagency-adaptationprogress-report.pdf

White paper describing status and capacity of the U.S. to adapt to a changing climate. Adaptation and resilience key themes. Outlines goals of task force in developing a national adaptation strategy due for report to the President in Fall 2010 required by Executive Order 13514.

Desotelle Consulting et al. 2006. Great Lakes Needs Assessment: Issue Area: Coastal Community Development. Report produced for the Great Lakes Commission and NOAACoastal Services Center: Charleston, SC. Available at: http://glc.org/regionalneeds/documents/FinalCCDNeedsAssessmentJuly2006.pdf

NOAA model twelve step needs assessment. Rubric of Regional, State, and Local target audience; need for in-depth interviews with end user of programs.

MRAG Americas. Feb 2009. Trends in Resource Management Needs and Issues: a Literature Review. Report submitted to the NOAA Coastal Services Center: Charleston, SC. Available at: <http://www.csc.noaa.gov/needsassesments/Coastal_Literature_Review.pdf>

Literature review of coastal and resource management issues and needs. Review of surveys, needs assessments, and other publications. Centers on theme areas of Coastal and Ocean planning, Coastal Conservation, and Hazard Resilience. Found the most thorough method of data collection is a stepped approach similar to the NOAA Needs Assessment steps. Recommends interviews, focus groups, and surveys for robust data collection.

MRAG Americas. April 2009. A Systematic Review of the Needs and Issues of the U.S. Coastal Resource Management Community: A Qualitative Meta-Analysis. Report submitted to the NOAA Coastal Services Center: Charleston, SC. Available at
http://www.csc.noaa.gov/needsassesments/Coastal_Meta_Analysis.pdf

Needs assessed on main themes of Coastal Conservation, Coastal and Ocean Planning,and Hazards Resilience. Covers all coastal U.S., including Great Lakes region. Web-based surveys reduce response time commitments and likely increased participation. Coastal management community well-represented in data but limited for regional ocean observing system community.

National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center. 2008. Summary Report for the Coastal Ecosystem-Based Management Course Needs Assessment.NOAA/CSC/RPT 08-01. Charleston, SC: NOAA Coastal Services Center.
Available at:

<http://www.csc.noaa.gov/needsassesments/(Economica%20Based%20Management)%20CSC% 20EBM%20Training%20Needs%20Assessment_final.pdf>

Survey of 254 professionals in U.S. coastal regions regarding ecosystem based Management knowledge and tools to evaluate needs for training programs. Found roughly 80% respondents involved stakeholders in collaborative process often, and would welcome training that improved skills in this area.

Safford, T., Thompson, J., and P. Scholz. 2005. Storm Surge Tools and Information: A User Needs Assessment. NOAA Coastal Services Center: Charleston, SC. Available at: <http://www.csc.noaa.gov/needsassesments/(Storm%20Surge)%20finalstormsurgereport.pdf>

Storm surges in coastal areas needs assessment for coastal managers. Three phase data collection method includes interviews with professionals, on-line questionnaires, and focus groups. Storm preparedness needs in salty coast regions also relevant to Great Lakes region.

Angell, C. 2008. Needs Assessment Data Summary: Climate Training Topics. Coastal Training Program, Washington. Survey results available at: <http://www.surveymonkey.com/sr.aspx?sm=1Ojr0TH7ZyTcrekrECDkWrykP4ETjgHL6uOuMo_2fssFE_3d>

Survey of 209 professionals in Washington State regarding climate change issues and relevance to job position and level of management. Survey data very useful to inform audience characterization and profile, as well as potential ‘invisible’ target audiences. Tribbia, John and Susanne C. Moser. 2008. More than information: what coastal managers need to plan for climate change. *Environmental Science & Policy 11* March (2008):315-328.

Keywords: Climate change, Sea-level rise, Coastal impacts, Coastal zone management, Information needs, and Boundary organization. Interview and survey research of managers and policy-makers in California. Recommendations of how inform and design science based tools to assist in climate change adaptation decisions.

Climate Vulnerability and Risk Assessments

Climate Vulnerability Assessment

Adapting to Climate Change: A Planning Guide for State Coastal Managers
National Oceanic and Atmospheric Administration Office of Ocean and Coastal Resource Management (Working Draft March 2010)

Chapter 4 describes the elements of a vulnerability assessment--including exposure, impacts, potential losses, adaptive capacity, and information regarding tools and data sources for such assessments.

Adger, N. (2006) "Vulnerability." *Global Environmental Change*. Vol. 16. No 3. 268-281.

This paper reviews research traditions of vulnerability to environmental change and the challenges for present vulnerability research in integrating with the domains of resilience and adaptation. Vulnerability is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt. Antecedent traditions include theories of vulnerability as entitlement failure and theories of hazard. Each of these areas has contributed to present formulations of vulnerability to environmental change as a characteristic of social-ecological systems linked to resilience. Research on vulnerability to the impacts of climate change spans all the antecedent and successor traditions. The challenges for vulnerability research are to develop robust and credible measures, to incorporate diverse methods that include perceptions of risk and vulnerability, and to incorporate governance research on the mechanisms that mediate vulnerability and promote adaptive action and resilience. These challenges are common to the domains of vulnerability, adaptation and resilience and form common ground for consilience and integration.

Chicago Climate Action Plan

The city has a plan for mitigating its impact on climate change that also includes plans for adaptation. Within this, there is data on how to calculate risks, which can be used to determine the most effective ways to allocate resources. A risk is scored based on its likelihood and the magnitude of its consequence. The impacts are divided into categories such as Water, Health, Ecosystems, and Infrastructure, each of which has subcategories. Each identified risk is scored individually, and the various impacts divided into high, medium, low risk classifications. Then the study provides a rough time frame in which people would start to experience thee impacts. This allows the city to prioritize its adaptation plans.
www.chicagoclimateaction.org/filebin/pdf/Chicago_Quick_Guide_to_Adaptation.pdf

Facing Hazards and Disasters: Understanding Human Dimensions (2006)
Committee on Disaster Research in the Social Sciences: Future Challenges and

Opportunities, National Research Council. Washington DC: The National Academies.

Social science research conducted since the late 1970s has contributed greatly to society's ability to mitigate and adapt to natural, technological, and willful disasters. However, as evidenced by Hurricane Katrina, the Indian Ocean tsunami, the September 11, 2001 terrorist attacks on the United States, and other recent events, hazards and disaster research and its application could be improved greatly. In particular, more studies should be pursued that compare how the characteristics of different types of events—including predictability, forewarning, magnitude, and duration of impact—affect societal vulnerability and response. This book includes more than thirty recommendations for the hazards and disaster community.

Informing Decisions in a Changing Climate. (2009) Panel on Strategies and Methods for Climate-Related Decision Support; National Research Council. Washington DC: The National Academies Press.

Informing Decisions in a Changing Climate examines the growing need for climate-related decision support--that is, organized efforts to produce, disseminate, and facilitate the use of data and information in order to improve the quality and efficacy of climate-related decisions. Drawing on evidence from past efforts to organize science for improved decision making, it develops guidance for government agencies and other institutions that will provide or use information for coping with climate change. This volume provides critical analysis of interest to agencies at every level, as well as private organizations that will have to cope with the world's changing climate.

Schneider, S. H., S. Semenov, A. Patwardhan, I. Burton, C. H. D. Magadza, M. Oppenheimer, A. B. Pittock, A. Rahman, J. B. Smith, A. Suarez, and F. Yamin. (2007). "Assessing key vulnerabilities and the risk from climate change." In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, editors. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Pages 779-810. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.
www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter19.pdf

This chapter of the IPCC report focuses on risk and vulnerability assessment. It identifies seven criteria from the literature that may be used to identify key vulnerabilities, and then describes some potential key vulnerabilities identified using these criteria. The criteria are: magnitude of impacts; timing of impacts; persistence and reversibility of impacts; likelihood (estimates of uncertainty) of impacts and vulnerabilities and confidence in those estimates; potential for adaptation; distributional aspects of impacts and vulnerabilities; and importance of the system(s) at risk.

B. Smit, B. and J. Wandel. (2006) "Adaptation, adaptive capacity and vulnerability." *Global Environmental Change* 16 (3), pp. 282–292.

Abstract: This paper reviews the concept of adaptation of human communities to global changes, especially climate change, in the context of adaptive capacity and vulnerability. It focuses on scholarship that contributes to practical implementation of adaptations at the community scale. In numerous social science fields, adaptations are considered as responses to risks associated with the interaction of environmental hazards and human vulnerability or adaptive capacity. In the climate change field, adaptation analyses have been undertaken for several distinct purposes. Impact assessments assume adaptations to estimate damages to longer-term climate scenarios with and without adjustments. Evaluations of specified adaptation options aim to identify preferred measures. Vulnerability indices seek to provide relative vulnerability scores for countries, regions or communities. The main purpose of participatory vulnerability assessments is to identify adaptation strategies that are feasible and practical in communities. The distinctive features of adaptation analyses with this purpose are outlined, and common elements of this approach are described. Practical adaptation initiatives tend to focus on risks that are already problematic, climate is considered together with other environmental and social stresses, and adaptations are mostly integrated or mainstreamed into other resource management, disaster preparedness and sustainable development programs.

Using HAZUS-MH for Risk Assessment: How-To Guide. FEMA Publication 433.

This How-To Guide is designed to help users prepare standardized, scientifically based risk assessments with the Hazards U.S. Multi-Hazard (HAZUS-MH) software.

Heat Vulnerability

Reid, Colleen E., O'Neill, Marie S., Gronlund, Carina J., Brines, Shannon J., Brown, Daniel G., Diez-Roux, Ana V., Schwartz, Joel. (2009) "Mapping Community Determinants of Heat Vulnerability." *Environmental Health Perspectives.* Vol. 117. No. 11: 1730-1736.

This article describes how evidence that heat waves can result in both increased deaths and illness is substantial, and concern over this issue is rising because of climate change. It argues that adverse health impacts from heat waves can be avoided, and epidemiologic studies have identified specific population and community characteristics that mark vulnerability to heat waves. The authors state that their objectives are to situate vulnerability to heat in geographic space and identify potential areas for intervention and further research.

Biodiversity and Species Vulnerability

Great Lakes Coastal Wetland Communities: vulnerabilities to climate change and responses to adaptation strategies. (2006) Environment Canada: Ottawa, ON.

A collaborative research project was undertaken to assess the vulnerability of selected wetlands on Lake Ontario (Presqu'ile Bay, Hay Bay, Lynde Creek, and

South Bay wetlands), Lake Erie (Long Point, Turkey Point, Dunnville, and Rondeau wetlands), and Lake St. Clair (Mitchell's Bay) to climate change. The integrated assessment utilized literature reviews, field surveys, stakeholder engagement, and modeling to explore responses of Great Lakes coastal wetland communities (wetland vegetation and associated wetland dependent birds and fishes) to historical and projected water level changes, and human-directed adaptations to changing water levels - infrastructure (lake regulation and dyking) and land use policy - to maintain ecosystem functions and values.

Doka, S.E., C.N. Bakelaar, and L.D. Bouvier. (2006) *Implications of climate change for coastal fishes and habitats.* Annual Conference on Great Lakes Research. Vol. 49

The objectives of this project were two-fold. One, to predict the biotic response of fish guilds to habitat changes that result from anticipated water levels and temperatures after 50 years of climate change. Two, to assess the fish response in wetlands after adaptation strategies (such as water level regulation by dams and dyking) are implemented. We assessed probable changes in fish habitat availability and suitability, including changes in wetland vegetation, for nearshore fish assemblages under different climate change scenarios. A fish habitat supply analysis for different thermal guilds was conducted that suggested different guilds may be limited in the future. Also, proposed water regulation schemes and dyking were evaluated in selected wetlands of the lower Great Lakes. In addition, the vulnerability of current fish assemblages in coastal wetlands was assessed. Results indicated that site- specific responses can vary but productive coastal habitats will decrease under future low water level conditions, especially. Proactive adaptation strategies will be discussed in light of projected nearshore changes and vulnerabilities of species.

Hebb, A.J., L.D. Mortsch and P.J. Deadman (2006). *Vulnerability of Great Lakes Coastal Wetland Vegetation Communities to Water Level Fluctuations*. Annual Conference on Great Lakes Research. Vol. 49

Projected lake level changes from climate change assessments were applied to a rule based wetland vegetation response model to assess the potential effects of climate change on wetland vegetation communities in eight wetlands on Lakes Ontario and Erie. The rule-based model was developed in a GIS to simulate wetland vegetation response to water level fluctuations based on water depth, duration of hydrologic condition, and the tolerance ranges of wetland vegetation to water level conditions. Water level change fields from four climate change scenarios were applied to the historical water level time series. The response model was used to simulate wetland vegetation distribution and abundance with a changed climate for a low and high initialization of water level condition. The modeled climate change affected wetland vegetation communities were compared to base case conditions to calculate changes in the wetland and assess climate change effects. As water levels declined, all wetlands experienced a decrease in open water and an increase in meadow marsh and treed/shrub vegetation. The hydrogeomorphic form of the wetland and initial water level condition were

important in influencing community outcomes.

Meyer, S., M. Galloway, G. Grabas, J. Ingram (2006). "Vulnerability of wetland plant communities in Great Lakes coastal wetlands to climate-induced hydrological change" *Great Lakes coastal wetland communities: vulnerabilities to climate change and response to adaptation strategies*. Pp. 21-36

The hydrological vulnerability of selected wetland plant species/communities in coastal wetlands on the lower Great Lakes based on a number of environmental preferences, life history traits, and population parameters is reviewed. A hydrological vulnerability index is used to compare the vulnerability of coastal wetland plants to climate-induced hydrologic change.

Mortsch, L.D. (1998). "Assessing the impact of climate change on the Great Lakes shoreline wetlands." *Climatic Change* Vol. 40, no. 2, pp. 391-416

Great Lakes shoreline wetlands are adapted to a variable water supply. They require the disturbance of water level fluctuations to maintain their productivity. However, the magnitude and rate of climate change could alter the hydrology of the Great Lakes and affect wetland ecosystems. Wetlands would have to adjust to a new pattern of water level fluctuations; the timing, duration, and range of these fluctuations are critical to the wetland ecosystem response. Two "what if" scenarios: (1) an increased frequency and duration of low water levels and (2) a changed temporal distribution and amplitude of seasonal water levels were developed to assess the sensitivity of shoreline wetlands to climate change. Wetland functions and values such as wildlife, waterfowl and fish habitat, water quality, areal extent, and vegetation diversity are affected by these scenarios. Key wetlands are at risk, particularly those that are impeded from adapting to the new water level conditions by man-made structures or geomorphic conditions. Wetland remediation, protection and enhancement policies and programs must consider climate change as an additional stressor of wetlands.

Williams, S. E., L. P. Shoo, J. L. Isaac, A. A. Hoffmann, and G. Langham (2008). "Towards an integrated framework for assessing the vulnerability of species to climate change." *PLoS Biology* 6:2621-2626

The authors' goal is a complete working framework for assessing the vulnerability of species that explicitly links: the various components of biotic vulnerability; the regional and local factors determining exposure to climatic change; the potential for both evolutionary and ecological responses, resilience, and active management to mediate the final realized impacts; and the potential for feedback effects. Such a framework would integrate and guide thought, research programs, and policy in the biodiversity/climate change arena and allow significant gaps in knowledge to be clearly identified. They present a conceptual framework that addresses these challenges.

Adaptation

National and Regional Adaptation Resources

Adger, W. N., N. W. Arnell, and E. L.Tompkins (2005). "Successful adaptation to climate change across scales." *Global Environmental Change* 15:77-86
Abstract. Climate change impacts and responses are presently observed in physical and ecological systems. Adaptation to these impacts is increasingly being observed in both physical and ecological systems as well as in human adjustments to resource availability and risk at different spatial and societal scales. We review the nature of adaptation and the implications of different spatial scales for these processes. We outline a set of normative evaluative criteria for judging the success of adaptations at different scales. We argue that elements of effectiveness, efficiency, equity and legitimacy are important in judging success in terms of the sustainability of development pathways into an uncertain future. We further argue that each of these elements of decision-making is implicit within presently formulated scenarios of socio-economic futures of both emission trajectories and adaptation, though with different weighting. The process by which adaptations are to be judged at different scales will involve new and challenging institutional processes.

Center for Science in the Earth System (The Climate Impacts Group), King County, Washington, and ICLEI Local Governments for Sustainability. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. www.cses.washington.edu/db/pdf/snoveretalgb574.pdf

Practical information on why and how governing bodies can prepare for climate change. This includes ideas about how to build public support, how to collect necessary data, do vulnerability assessments, evaluate tools, establish benchmarks and measure progress.

National Oceanic and Atmospheric Administration (2010). *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. NOAA Office of Ocean and Coastal Resource Management.
http://coastalmanagement.noaa.gov/climate/adaptation.html

This guide describes the steps that make up a planning process and measures that can be incorporated into an adaptation plan. Although geared toward state-level managers, the information is applicable for community-level planning as well. It includes numerous case studies of adaptation strategies, information on regulatory incentives for managing implementation, and funding resources. The text notes that climate change impacts are not separate from

existing coastal management issues and emphasizes the benefits of incorporating adaptation into existing sustainability and hazard planning.

National Research Council (2009). *Informing Decisions in a Changing Climate*. Panel on Strategies and Methods for Climate-Related Decision Support
This PDF is available from the National Academies Press at:
http://www.nap.edu/catalog/12626.html

In response to a growing demand from leaders in both the public and private sectors for information and more effective ways to support climate-related decisions, this report sets forth the foundations for improved decision support with a set of principles and a framework for decision support processes that include information, strategies, and methods. Meeting the nation's decision support needs will require involvement of organizations across the country. Leadership from the federal government will be essential. The report concludes that the federal government's efforts should be undertaken through a new integrated, interagency initiative with both service and research elements. The panel offers nine recommendations (see Summary pp. 2ff) to facilitate effective development of climate-related decision support capabilities across many levels of governments and the private sector in our nation. It stresses the importance of regional management and cites the core principles that characterize effective decision support in such areas as public health, natural resource management, and environmental risk management as applicable to informing decisions about responses to climate change.

Tang, Zhenghong, Samuel D. Brody, Courtney Quinn, Liang Chang, and Ting Wei (2010). "Moving from agenda to action: evaluating local climate change action plans." *Journal of Environmental Planning and Management*, Volume 53, Issue 1 : 41-62

Climate change is conventionally recognized as a large-scale issue resolved through regional or national policy initiatives. However, little research has been done to directly evaluate local climate change action plans. This study examines 40 recently adopted local climate change action plans in the US and analyses how well they recognize the concepts of climate change and prepare for climate change mitigation and adaptation. The results indicate that local climate change action plans have a high level of 'awareness', moderate 'analysis capabilities' for climate change, and relatively limited 'action approaches' for climate change mitigation. The study also identifies specific factors influencing the quality of these local jurisdictional plans. Finally, it provides policy recommendations to improve planning for climate change at the local level.

UK Climate Impacts. www.ukcip.org.uk/index.php

UK Climate Impacts Program website. Could be a model for aspects of the adaptation module. Has a "Wizard" to assess vulnerability and help set up a plan.

USAID. *Adapting to Coastal Climate Change: A Guidebook for Development Planners*. www.usaid.gov/our_work/crosscutting_programswater/docs/coastal_adaptation/adapting_to_coastal_climate_change.pdf

Great Lakes Adaptation Information

Bamberger, E., K. Parlee, and B. Mehdi. *Adapting to Climate Change Impacts on the Great Lakes Watershed: A summary of knowledge gaps, barriers, and priority research needs*. C-CIARN Ontario, Laurentian University, Ramsey Lake Road, Sudbury, ON, P3E 2C6

The Canadian Climate Impacts and Adaptation Research Network (C-CIARN) is a national network that facilitates the generation of new climate change knowledge by linking researchers with decision-makers to address key issues. Part of C-CIARN's mandate is to identify current impacts and adaptation strategies, and assist in the development of appropriate adaptation measures for the future. A series of national and regional workshops have identified issues, outlined current adaptation strategies and discussed results from research projects and case studies that address climate change impacts in the Great Lakes watershed. Topics covered include impacts on water quality and quantity, fluctuating water levels, navigability, biodiversity, municipal water intake infrastructure, coastal erosion and shoreline stability, tourism, recreation, hydropower, and jurisdictional/legal issues. Ensuing discussions have resulted in the identification of knowledge gaps that create barriers for developing appropriate adaptation strategies to these climate change impacts. These knowledge gaps form the basis for a climate change research agenda relevant to the Great Lakes watershed. (search CSA Illumina: cc, adaptation, GL)

Chiottl, Q., & Lavender, B (2008). "Ontario." Chapter 6 in D.S. Lemmen, F.J. Warren, J. LaCroix, J. and E. Bush, editors. *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Ottawa, ON. Government of Canada

The authors spend most of the chapter talking about impacts of climate change, but toward the end they assess adaptation possibilities. They suggest that Ontario has the ability to adapt based on a variety of indicators, such as economic wealth, technology, information and skills, infrastructure, institutions, social capital and equity. However, "this capacity is not uniform across subregions and sectors. Adaptation is starting to occur in Ontario. For example, climate change has been incorporated into some long-term planning and decision-making, most notably by some conservation authorities (e.g. for storm-water management) and public health departments (e.g. with heat-health alert systems). Opportunities exist for mainstreaming adaptation to climate change into decision-making through, for example, the Clean Water Act, and other legislation, regulations or planned activities that relate to, among other things, infrastructure renewal programs, low-water response programs and growth strategies."

De Loe, R., R. Kreutzwiser, and L. Moraru (2001). "Adaptation options for the near term: climate change and the Canadian water sector." *Global Environmental Change, Part A: Human and Policy Dimensions*. Vol. 11, no. 3, pp. 231-245

Climate change poses significant challenges for the Canadian water sector. This paper discusses issues relating to the selection of proactive, planned adaptation measures for the near term (next decade). A set of selection criteria is offered, and these are used in three cases to illustrate how stakeholders can identify measures appropriate for the near term. Cases include municipal water supply in the Grand River basin, Ontario; irrigation in southern Alberta; and commercial navigation on the Great Lakes. In all three cases, it is possible to identify adaptations to climate change that also represent appropriate responses to existing conditions; these should be pursued first.

De Loee, R.C. and R. Kreutzwiser. Climate Variability, Climate Change and Water Resource Management in the Great Lakes. Department of Geography, University of Guelph, Guelph, Ontario, N1G 2W1, Canada

Water managers always have had to cope with climate variability. All water management practices are, to some extent, a response to natural hydrologic variability. Climate change poses a different kind of problem. Adaptation to climate change in water resource management will involve using the kinds of practices and activities currently being used. However, it remains unclear whether or not practices and activities designed with historical climate variability will be able to cope with future variability caused by atmospheric warming. This paper examines the question of adaptation to climate change in the context of Canadian water resources management, emphasizing issues in the context of the Great Lakes, an important binational water resource.

Doering, Otto, M. Habeck, et al (1997). "Mitigation Strategies and Unforeseen Consequences: A Systematic Assessment of the Adaptation of Upper Midwest Agriculture to Future Climate Change." *World Resource Review*. Vol. 9, (4: 447)

The importance of agriculture to the Midwestern US Great Lakes states is indicated by the land-use pattern of the region: 52% of all land in the fives states is used for crops and pasture. Changes in regional climate will necessitate a change in these land-use patterns. While little can be expected between now and 2050 to mitigate potential climate change, adaptations are expected, which may be counter-intuitive and possibly have unforeseen consequences. An integrated assessment is presented of this adaptation, using simulation of the impacts of global change on crop production, estimates of the efficiency of new technologies, and modeling of the decision processes that would likely drive adaptation by farmers. The simulation and modeling procedures used are detailed. The focus is on early corn planting as an adaptive strategy. The simulation results suggest an increase in double cropped wheat in areas north of those where it is now common, and corn planted earlier than it is now. The use of early corn, however, carries with it the risk of late-spring freezes, which would necessitate replanting. The value of a frost-resistant corn variety could be quite substantial.

Mortsch, L., J. Ingram, A. Hebb, and S. Doka, editors (2006). *Great Lakes Coastal Wetland Communities: Vulnerability to Climate Change and Adaptation Strategies*. Final Report submitted to the Climate Change Impacts and Adaptation Program, Natural Resources Canada. Environment Canada and the Department of Fisheries and Oceans, Toronto, Ontario.

This report describes probable impacts of climate change on great Lakes ecosystems (vegetation, fish, and birds) based on computer modeling. It then evaluates possible adaptation scenarios. "Human adaptations to climate change involving coastal wetlands and lower water levels could take several forms – wetland dyking, large-scale water level regulation, and coastal land-use planning changes. Wetland modelling and stakeholder input for this project indicated that 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 should be a high priority. Therefore, mechanisms are required to incorporate climate change trends and potential impacts information, such as projected changes in wetland distribution and functioning, into policy and planning at various levels of government. No examples were found on current land use planning or policy within the Great Lakes region that utilized human-directed adaptation to climate change to reduce impacts to Great Lakes coastal wetlands or any other natural coastal areas. Ten Planning Criteria and a Coastal Corridor Concept were developed as preliminary ideas proposed for the future protection of coastal areas and these concepts were discussed with stakeholders during the second year of the project. A limited development coastal corridor would help maintain the functioning of natural shoreline processes under a changing climate while also protecting property and potentially enhancing public access at low, long-term costs."

wicci.wisc.edu/index.htm

Wisconsin's website for WICCI, the Wisconsin Initiative on Climate Change Impacts. WICCI "assesses and anticipates climate change impacts on specific Wisconsin natural resources, ecosystems and regions; evaluates potential effects on industry, agriculture, tourism and other human activities; and develops adaptation strategies that can be implemented by businesses, farmers, public health officials, municipalities, resource managers and other stakeholders." The working groups, drawn from staff at the DNR and the University of Wisconsin, provide information related to specific region. This includes general information on vulnerabilities and adaptations appropriate to each region.

Community-level Adaptation Information

Chicago Action Plan
www.chicagoclimateaction.org/

The city has a plan for mitigating its impact on climate change that also addresses adaptation. It includes information on the effects of climate change, current city initiatives, and actions that can be taken by businesses and residents. The site provides links to further data. The following reports are especially useful: ---Julia Parzen, editor (March 2008). *Chicago Quick Guide to Climate Change Preparation: Adapting to the Physical Impacts of Climate Change.* --Julia Parzen, editor (July 2009). *Lessons Learned: Creating the Chicago Climate Action Plan.*

New Hampshire Energy and Climate Collaborative. http://nhcollaborative.org/

The New Hampshire Climate Action Plan includes both mitigation and adaptation in a holistic plan. The adaptation recommendations include strengthening protection for natural resources and building ecosystem resilience. The proposal also recommends developing a coherent Adaptation Plan (in the future). One unusual feature of the New Hampshire plan is the recommended formation of a public/private partnership, the New Hampshire Energy and Climate Collaborative, to oversee and guide implementation. The primary purpose of the collaborative is to track and facilitate implementation of the plan’s recommendations and to report to the governor, legislature, and general public on progress toward achieving the desired outcomes.

Flood Prevention

"Case Study – A Cape Cod Community Prevents New Residences in Floodplains Lessons Learned from Chatham's legally successful conservancy districts." Town of Chatham, Storm Smart Coasts Factsheet
http://www.mass.gov/czm/stormsmart/resources/stormsmart_chatham.pdf
Homepage: http://www.mass.gov/czm/stormsmart/

The website for Chatham, Mass, provides an overview of regulations and information intended to prevent flood damage. This includes practical information on how to interpret FIRM and FIS reports, what their limitations are, and what other data can supplement them. There are also suggestions for urban planning to develop master plans that consider changing risk levels and the importance of zoning for those potential changes. This includes planning to make infrastructure resilient and resistant to hazards. The city website provides a good model for long-term adaptation planning.

ASCE. *So, You Live Behind a Levee!*
http://content.asce.org/ASCELeveeGuide.html

The American Society of Civil Engineers' new public education booklet, *So, You Live Behind a Levee!*, describes the probability that levees will fail to protect people from floods and lists ways that people and communities can better protect themselves against future flood threats. The primary goal of the book seems to be increasing funding for levee improvements, and it lacks data on greenbelts or other alternatives to levees, but the text has good maps of the current levee systems, nice charts for communicating about flood risks, and some practical advice on preparation.

FEMA (2003). *The 1993 Great Midwest Flood: Voices 10 years later*. A 10th-Anniversary Anthology of Stories of Hardship and Triumph collected by the U.S. Department of Homeland Security Federal Emergency Management Agency.
www.fema.gov/plan/prevent/bestpractices/Best_Practices-Great_Midwest_Flood.shtm

This account of the 1993 flood and recovery has sections describing the floodplain management plans in midwestern states. It describes how Illinois has reduced costs of flood damage by restoring floodplains and controlling development. This includes purchasing properties and removing structures. In Austin, Minnesota, a flood-prone block of homes was relocated to higher ground. Arnold, Missouri, utilized a buy-out program to shift people out of the floodplain and return that area to green space. These programs not only save money and prevent human suffering, they increase the amount of parkland and improve the communities.

FEMA publications: the following provide information on preventing flood damage:
---Design Guide for Improving Critical Facility Safety from Flooding and High Winds: Providing Protection to People and Buildings, Federal Emergency Management Agency. www.fema.gov/library/viewRecord.do?id=2441

---Engineering Principles and Practices of Retrofitting Floodprone Residential Structures, Federal Emergency Management Agency, www.fema.gov/library/viewRecord.do?id=1645

---Homeowner's Guide to Retrofitting: Six Ways to Protect Your House From Flooding, Federal Emergency Management Agency. www.fema.gov/library/viewRecord.do?id=1420

The Federal Emergency Management Agency (FEMA) has prepared this guide specifically for homeowners who want to know how to protect their homes from flooding. As a homeowner, you need clear information about the options available to you and straightforward guidance that will help you make decisions. This guide gives you both, in a form designed for readers who have little or no experience with flood protection methods or building construction techniques.

University of North Carolina. *Implementing Floodplain Land Acquisition Programs in Urban Localities*, Center for Urban & Regional Studies. http://people.vanderbilt.edu/~james.c.fraser/publications/Floddplain%20Project%20Report.Final.pdf

Snow Removal

Buffalo, NY. www.ci.buffalo.ny.us/Home/City_Departments/EMS/SeasonalTransportationPlan

Buffalo's Seasonal Transportation Plan considers issues of emergency travel routes due to weather-related road conditions that could be a model for other communities. This city also has one of the highest annual snowfalls in the Midwest due to "lake effect" snowfall patterns. After severe snowfalls caused problems in 2008, the city updated its plans for snow removal. These plans can be found at: www.bpdny.org/files/SnowRemovalExecutiveSummary.pdf

Stormwater Management

EPA. *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*. www.epa.gov/owow/NPS/lid/section438/pdf/final_sec438_eisa.pdf

Stormwater runoff in urban areas is one of the leading sources of water pollution in the United States. Traditional urban areas typically include large areas of impervious surfaces such as roads, sidewalks and buildings. These impervious surfaces prevent rainwater from infiltrating into the ground, and as a result, stormwater runs off these urban areas at higher rates and volumes. These higher stormwater rates and volumes can cause increased flooding and erosion, and more pollution to surface waters, among other impacts. This text the technical guidance for following new stormwater runoff requirements.

Green Infrastructure: Rain Gardens, etc

EPA. Managing Wet Weather with Green Infrastructure. cfpub.epa.gov/npdes/home.cfm?program_id=298

This EPA website has links to examples of green infrastructure and design. It also advocates preservation and restoration of natural landscape features such as forests, floodplains, and wetlands, as critical components of stormwater infrastructure.

EPA Reports on Water Resource Management and Protection:
---Stormwater Program, U.S. Environmental Protection Agency, Office of Water. http://cfpub.epa.gov/npdes/home.cfm?program_id=6

---Low Impact Development, U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. www.epa.gov/nps/lid/

---U.S. Army Corps of Engineers Coastal Hydraulics Laboratory Web Site. http://chl.erdc.usace.army.mil/

---Water Quality Scorecard: Incorporating Green Infrastructure Practices at the Municipal, Neighborhood, and Site Scale. U.S. Environmental Protection Agency. www.epa.gov/smartgrowth/water_scorecard.htm

Georgia. www.georgiaepd.org/Documents/CoastalStormwaterSupplement.html

The Coastal Stormwater Supplement to the Georgia Stormwater Management Manual provides Georgia's coastal communities with guidance on an integrated, green infrastructure-based approach to natural resource protection,

stormwater management, and site design that can be used to better protect coastal Georgia's natural resources from the negative impacts of land development and nonpoint source pollution. The manual seeks to shift the focus of stormwater management efforts from postconstruction alleviation of impacts to preconstruction prevention.

Massachusetts Water Resources Authority Deer Island Sewage Treatment Plant. www.mwra.com/03sewer/html/sewditp.htm

In the 1990s, the Massachusetts Water Resources Agency designed and built Boston's Deer Island wastewater treatment plant in consideration of sea level rise. Specifically, the plant was built 1.9 feet higher than required at the time to accommodate the amount of sea level rise projected to occur over the expected lifetime of the facility (~50 years). Although the focus is on planning for rising sea levels, this program has useful ideas for dealing with sewage treatment in areas where storm water flow and flooding are likely to increase

Milwaukee Metropolitan Sewerage District. http://v3.mmsd.com/

Established by Wisconsin state law, the Metropolitan Milwaukee Sewerage District is a regional government agency that provides water reclamation and flood management services. To help reduce the number of combined sewer overflow events and improve the water quality in Lake Michigan, the agency has invested in a number of green infrastructure projects. Programs include "Green Seams," a land acquisition program aimed at preserving lands that will help prevent flooding, and the Lake Michigan Rain Gardens Initiative. The website includes information about rain garden benefits, native plants for rain gardens, and grants to offset plant costs. The agency also promotes downspout disconnection and has partnered up with local businesses and municipalities to make rain barrels accessible to the public.

NACo. The National Association of Counties Green Infrastructure Program. www.naco.org/Template.cfm?Section=Environment,_Energy_and_Land_Use&template=/ContentManagement/ContentDisplay.cfm&ContentID=32928

NACo's Green Infrastructure Program helps counties to use management of natural resources to enhance water quality, abate flooding, lower heat in urban centers, lessen the impacts of climate change and build more resilient communities. It includes information on green roofs, rain Gardens, porous pavement, greenways, and greenbelts.

National Research Council (2009). *Urban Stormwater Management in the United States*. Washington DC: The National Academies Press (www.nap.edu)

Comprehensive overview of urban stormwater management processes with a focus on how to reduce runoff. This report describes urbanization and how it has contributed to pollution of waters, the challenges of regulating stormwater, the ways urbanization affects watersheds, and methods for monitoring and modeling water flow. Chapters 5 and 6, which focus on methods of water management, are particularly useful for climate adaptation planning. Chapter 5 describes traditional methods and chapter 6 provides information on green infrastructure and innovative techniques.

NEMO. National NEMO Network Programs.
nemonet.uconn.edu/programs/programs.htm

This website has links to pages describing land and water management programs in Minnesota, Wisconsin, India, Ohio, Pennsylvania, and New York. The programs are adapted to the needs of the states. For example, Ohio focuses on green infrastructure to reduce flooding, Indiana focuses on rural land management, and Minnesota teams up with Wisconsin to protect watersheds.

New Jersey's Coastal Blue Acres Program. www.state.nj.us/dep/greenacres/

This part of the Department of Environmental Protection’s Green Acres Program is designed to provide grants and loans to municipalities or counties to acquire important coastal lands for recreational and conservation purposes. To be eligible for acquisition through the Blue Acres Program, the land must have been severely damaged by storms, or is threatened by future storms, or serves as a buffer to protect other land from storm damage. The 1995 bond act that created the program appropriated $6 million (75 percent grant/25 percent loan) for the purchase of undeveloped land in high-risk erosion areas or property that serves important buffering roles. An additional $9 million was appropriated for the purchase of land severely damaged by storms (50 percent grant/50 percent loan). To be eligible for acquisition, the property must have lost at least 50 percent of its value due to storm damage.

Drought

Drought Management in Quakertown PA. Water Department webpage.
http://www.quakertownboro.com/water.html

This is a useful case for demonstrating the efficacy of conservation. The town was overdrawing its water supply. It created a regulation requiring all new construction and remodels to include efficient water fixtures. This was easy to implement through the existing construction permit process. This conservation measure resolved the shortage and prevented the need for expensive investment in new water sources.

Winstanley, Derek, James R. Angel, Stanley A. Changnon, H. Vernon Knapp, Kenneth E. Kunkel, Michael A. Palecki, Robert W. Scott, and H. Allen Wehrmann *The Water Cycle and Water Budgets in Illinois: A Framework for Drought and Water-Supply Planning.* www.isws.illinois.edu/iswsdocs/wcwbiil/WaterCycleandWaterBudgetsinIL.pdf

Illinois has included drought in its water supply planning. The report discusses both climate variability and change as factors that affect supplies. It analyzes historical climate records to quantify magnitudes and durations of previous droughts that have occurred throughout the state. "These historical data then can be used to characterize future droughts, based on the assumption that what has occurred in the past can occur again in the future. Climate change over periods of decades and centuries, as evidenced by changed amounts and frequencies of precipitation and temperature, also can influence water availability. Thus, this report also analyzes 150 years of climate records in Illinois for evidence of climate change, and uses the output from climate models to project possible future climate conditions in the region."

Winstanley, Derek, James R. Angel Timothy P. Bryant H. Vernon Knapp Michael A. Palecki Amy M. Russell H. Allen Wehrmann (2006). *Drought Planning for Small Community Water Systems*. Prepared for the Midwest Technology Assistance Center. www.isws.illinois.edu/pubdoc/CR/ISWSCR2006-01.pdf

This report is directed toward the systems managers of the Midwest Technology assistance Center region, which includes the 10 states of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin. The goals of this project are: 1) to provide basic considerations for an initial assessment of drought preparedness for small community water systems serving less than 10,000 persons in the 10 states in the MTAC region; and 2) to produce recommendations for conducting drought-sensitivity studies by small community water systems in the MTAC region. The report used information from state drought plans and other sources, and included data on climate variability to assess probable impacts and planning needs.

Heat Island Effect

Corburn, Jason (2009). "Cities, Climate Change and Urban Heat Island Mitigation: Localising Global Environmental Science." *Urban Studies* 46, no. 2:

413-427

Abstract. This paper explores how city planners engaged with global climate scientists to devise contextually relevant strategies to address the urban heat island effect—a potentially dangerous heat event expected to increase along with global warming. Drawing original data from the New York City Regional Heat Island Initiative, a collaborative effort between scientists and urban planners, the paper highlights how global climate science is ‘localised’ as researchers and policy-makers struggle to make technically legitimate and politically accountable decisions. The paper argues that the localisation of global science often involves a process of co-production, where technical issues are not divorced from their social setting and a diverse set of stakeholders engage in analytical reviews and the crafting of policy solutions. The paper argues that the co-production framework can contribute to more scientifically legitimate and publicly accountable decision-making related to urban climate change.

Naughton MP, Henderson A, Mirabelli MC, Kaiser R, Wilhelm JL, Kieszak SM, Rubin CH, McGeehin MA (2002). "Heat-related mortality during a 1999 heat wave in Chicago." *American Journal of Preventive Medicine*. Vol 22, Issue 4: 221-227.

Abstract: Background: During the summer of 1999, Chicago's second deadliest heat wave of the decade resulted in at least 80 deaths. The high mortality, exceeded only by a 1995 heat wave, provided the opportunity to investigate the risks associated with heat-related deaths and to examine the effectiveness of targeted heat-relieving interventions.

Methods: We conducted a case-control study to determine risk factors for heat-related death. We collected demographic, health, and behavior information for 63 case patients and 77 neighborhood-and-age-matched control subjects and generated odds ratios for each potential risk factor.

Results: Fifty-three percent of the case patients were aged <65 years, and psychiatric illness was almost twice as common in the younger than the older age group. In the multivariate analysis, the strongest risk factors for heat-related death were living alone and not leaving home dailyThe strongest protective factor was a working air conditioner. Over half (53%) of the 80 decedents were seen or spoken to on the day of or day before their deaths.

Conclusions: A working air conditioner is the strongest protective factor against heat-related death. The relatively younger age of case patients in 1999 may be due to post-1995 interventions that focused on the elderly of Chicago. However, social isolation and advanced age remain important risk factors. Individual social contacts and educational messages targeted toward at-risk populations during heat waves may decrease the number of deaths in these groups.

Poumadere, M., C. Mays, S. Le Mer, R. Blong (2005). "The 2003 heat wave in France: Dangerous climate change here and now." *Risk Analysis*. Vol 25, Issue 6: 1483-94

Abstract: In an analysis of the French episode of heat wave in 2003, this article highlights how heat wave dangers result from the intricate association of natural and social factors. Unusually high temperatures, as well as socioeconomic vulnerability, along with social attenuation of hazards, in a general context where the anthropogenic contribution to climate change is becoming more plausible, led to an excess of 14,947 deaths in France, between August 4 and 18, 2003. The greatest increase in mortality was due to causes directly attributable to heat: dehydration, hyperthermia, heat stroke. In addition to age and gender, combinatorial factors included preexisting disease, medication, urban residence, isolation, poverty, and, probably, air pollution. Although diversely impacted or reported, many parts of Europe suffered human and other losses, such as farming and forestry through drought and fires. Summer 2003 was the hottest in Europe since 1500, very likely due in part to anthropogenic climate change. The French experience confirms research establishing that heat waves are a major mortal risk, number one among so-called natural hazards in postindustrial societies. Yet France had no policy in place, as if dangerous climate were restricted to a distant or uncertain future of climate change, or to preindustrial countries. We analyze the heat wave's profile as a strongly attenuated risk in the French context, as well as the causes and the effects of its sudden shift into amplification. Research and preparedness needs are highlighted.

Stone, Brian (2005). Urban Heat and Air Pollution: An Emerging Role for Planners in the Climate Change Debate. *Journal of the American Planning Association.* Chicago. Vol. 71, Iss. 1; pg. 13, 13 pgs

Abstract. This article presents empirical evidence linking recent fluctuations in regional temperatures to enhanced ozone formation within the country's 50 largest metropolitan regions. The results of an analysis of regional climate and ozone formation during the 1990s indicate that annual violations of the national ozone standard were more strongly associated with regional temperatures than with the emissions of regulated ozone precursors from mobile and stationary sources. Based on the results of this analysis, I argue that the air quality management strategies outlined in the Clean Air Act may be insufficient to control ozone formation due to ongoing and unanticipated changes in global and regional climate. I further argue that the emergence of urban heat as a significant air "pollutant" demands a strategic response from the field of urban planning. The article concludes with a discussion of the linkages between urban form and regional temperature and outlines a set of design strategies that have proven successful in mitigating urban heat production.

www.planning.org/cityparks/briefingpapers/climatechange.htm

Briefing paper describing how urban parks can be used to mitigate the heat island effect in 4 ways. 1) Parks moderate artificially raised temperatures. 2) Parks create breezes. 3) Parks help reduce local precipitation anomalies. 4) Parks sequester carbon and other pollutants that may increase local and global heat. Excellent bibliography.

Shoreline Infrastructure

Auld, Heather, Paul A. Gray, Don Haley, Joan Klaassen, Heather Konnefat, Don MacIver, Don McNicol, Peter Nimmrichter, Karl Schiefer, Mark Taylor (2006). *Coastal zone and Climate Change on the Great Lakes: Final Report*. Natural Resources Canada

This report addresses impacts and adaptation for coastal communities on each of the Great Lakes. It notes that adaptation must be appropriate to the needs of different communities and gives examples. It presents adaption as both a reaction to threats and a way to take advantage of opportunities. It notes that changes in lake levels may be the factor causing the widest impact and that there is a possibility of attempting to regulate water levels in Lake Huron. It stresses prevention of damage from weather events as a cost-effective adaptation. It also notes that uncertainties in our knowledge will necessitate further research and monitoring.

Michigan Sea Grant. Clean Marina Program. http://www.miseagrant.umich.edu/cmp/index.html.

This program provides information and guidelines for management of marinas that protects ecosystems and water quality.

NOAA. *Smart Growth for Coastal and Waterfront Communities* is a guidance document for planners, government officials, developers, nonprofit groups, and coastal and waterfront residents, that describes the coastal and waterfront smart growth elements to help communities plan for growth while protecting their natural and economic resources, maritime heritage, and traditional sense of place. The guide includes an overview of growth-related challenges and opportunities faced by coastal and waterfront communities, a description of tools and techniques for applying smart growth elements, and case studies that illustrate the smart growth in action. A number of the suggestions can be applied to climate change adaptation. http://coastalsmartgrowth.noaa.gov/

Virginia. www.deq.virginia.gov/coastal/livingshore.html

The Virginia Coastal Zone Management Program is working with partners to promote Living Shorelines. The state's Living Shoreline Strategy, funded through Section 309 of the Coastal Zone Management Act, includes a Living Shoreline Summit (in conjunction with the Maryland Coastal Zone Management Program), revisions to the state's wetlands guidelines, research to further document the habitat value and refine the design of living shorelines, a protocol for determining the feasibility of living shorelines on a reach (shoreline segment) basis, additional shoreline situation reports and shoreline evolution studies to better inform local shoreline management decisions, a shoreline planning guidance document to help localities proactively address shoreline management issues and meet comprehensive planning requirements, a brochure and website for landowners, and a design manual and training program for contractors.

Wisconsin Department of Natural Resources *Creating an Effective Shoreland Zoning Ordinance: A Summary of Wisconsin Shoreland Zoning Ordinances* are available online at http://dnr.wi.gov/org/water/wm/dsfm/shore/local.htm

Ecosystem Resiliency

Chicago Wilderness Climate Change Task Force (March 2010). "Chicago Wilderness Climate Action Plan for Nature." http://naturalsystems.uchicago.edu/urbanecosystems/calumet/cdrom/plans/CW%20Climate%20Action%20Plan%20for%20Nature%20final%2017%20March%202010.pdf

Chicago Wilderness is an organization focused on conservation. Recognizing climate change as a new stress on wilderness, they developed this Action Plan for improving ecosystem resiliency in the Chicago area. They focus on efforts that are relatively easy to implement quickly because of limitations in staff and funding. The recommended actions include: adding climate change mitigation and adaptation to educational materials; promoting land conservation as part of a regional emissions mitigation plan; improving resiliency to help with adaptation, planning for impacts from changes in stormwater, groundwater, and drought, and the need for increased monitoring. The report includes information about adaptation planning, dealing with uncertainties, and climate change tools for conservation practitioners.

Conservation Resource Alliance. The Conservation Fund: Green Infrastructure Case Study Series
http://www.greeninfrastructure.net/sites/greeninfrastructure.net/files/5-CRA%2008.30.05_0.pdf
Conservation Resource Alliance's Wild Link and River Care Programs are good Michigan case-study examples for improving ecosystem resiliency.

Doka, S., J. Ingram, L. Mortsch, A. Hebb (2006). "Preparing for climate change: assessing adaptation strategies for coastal wetlands." *Great Lakes coastal wetland communities: vulnerabilities to climate change and response to adaptation strategies*. pp. 179-186

Three adaptation strategies to climate change were investigated and evaluated for Great Lakes coastal wetlands. The evaluated adaptations are a subset of measures that are already used in the lower Great Lakes and impact water levels as well as coastal areas. The subset includes: lake-wide water level regulation on Lake Ontario; dyking of wetlands in Lakes Ontario, Erie, and St. Clair; and land use planning and policy

Glick, Patty, Amanda Staudt and Bruce Stein (March 2009) *A New Era for Conservation: Review of Climate Change Adaptation Literature.* National Wildlife Federation

This study focuses on natural resource management to protect biodiversity as the climate changes. Chapters provide adaptation strategies for specific habitat types, and each section has a case study to supplement the general data. Of interest for the GL region: chapters on Forests (case study from SW Oregon); Grasslands and shrublands (Idaho); and most useful of all, Freshwater systems in rivers, streams, and floodplains (Massachusetts).

Lawler, Joshua J (2009). "Climate Change Adaptation Strategies for Resource Management and Conservation Planning" *The Year in Ecology and Conservation Biology*. Vol 1162, P. 79-98

Abstract: Recent rapid changes in the Earth's climate have altered ecological systems around the globe. Global warming has been linked to changes in physiology, phenology, species distributions, interspecific interactions, and disturbance regimes. Projected future climate change will undoubtedly result in even more dramatic shifts in the states of many ecosystems. These shifts will provide one of the largest challenges to natural resource managers and conservation planners. Managing natural resources and ecosystems in the face of uncertain climate requires new approaches. Here, the many adaptation strategies that have been proposed for managing natural systems in a changing climate are reviewed. Most of the recommended approaches are general principles and many

are tools that managers are already using. What is new is a turning toward a more agile management perspective. To address climate change, managers will need to act over different spatial and temporal scales. The focus of restoration will need to shift from historic species assemblages to potential future ecosystem services. Active adaptive management based on potential future climate impact scenarios will need to be a part of everyday operations. And triage will likely become a critical option. Although many concepts and tools for addressing climate change have been proposed, key pieces of information are still missing. To successfully manage for climate change, a better understanding will be needed of which species and systems will likely be most affected by climate change, how to preserve and enhance the evolutionary capacity of species, how to implement effective adaptive management in new systems, and perhaps most importantly, in which situations and systems will the general adaptation strategies that have been proposed work and how can they be effectively applied.
KEYWORDS: adaptation • adaptive management • climate change • conservation planning • management • scenario planning • triage

National Parks Conservation Association. *Climate Change and National Park Wildlife: A Survival Guide for a Warming World.* www.npca.org/climatechange/wildlife_survival/

This text starts with an account of how climate change will affect the wildlife in the national parks, then moves on the list actions. Many of these are useful for adaptation: to protect the places that will help wildlife survive as the climate changes; manage wildlife anticipating the changes ahead; and improve the ecological health of the national parks and their surrounding landscapes to give fish and wildlife a fighting chance to survive unnatural climate change.

Snell, E., L. Mortsch, M. Galloway (2006). "Land use planning." In *Great Lakes coastal wetland communities: vulnerabilities to climate change and response to adaptation strategies*. pp. 229-247.

Previously published reports on land use planning are discussed, and some of the options presented are explored more deeply, starting the discussion of how they might assist Ontario's Great Lakes coastal wetlands' adaptation to climate change. This is focused on ecosystem communities, not human communities.

UNEP. *The Role of Ecosystem Management in Climate Change Adaptation and Disaster Risk Reduction.* The Copenhagen Discussion Series. www.unep.org/climatechange/LinkClick.aspx?fileticket=rPyahT90aL4%3d&tabid=836&language=en-US

This report was prepared for the UNFCCC prior to the Copenhagen climate negotiations. It begins with an overview of the impacts of climate change on ecosystems, then turns to a discussion of ecosystem management. It defines a central role for ecosystem management in climate change adaptation and disaster risk reduction and their multifaceted linkages. It also assesses the challenges for enhanced ecosystem management for climate change adaptation and disaster risk reduction.

Administration/Implementation

Adger, W. Neil, Terry P. Hughes, Carl Folke, Stephen R. Carpenter, Johan Rockström. "Social-Ecological Resilience to Coastal Disasters." *Science* 12 August 2005. Vol. 309. no. 5737, pp. 1036 - 1039
Abstract: Social and ecological vulnerability to disasters and outcomes of any particular extreme event are influenced by buildup or erosion of resilience both before and after disasters occur. Resilient social-ecological systems incorporate diverse mechanisms for living with, and learning from, change and unexpected shocks. Disaster management requires multilevel governance systems that can enhance the capacity to cope with uncertainty and surprise by mobilizing diverse sources of resilience.

American Planning Association (2010). *Planning for a New Energy and Climate Future*

This APA report describes energy and climate issues as they are related to urban planning. Each chapter provides an overview of a specific topic, such as transportation or energy production, and then goes on to describe some measures for addressing the subject in urban planning. Case studies used throughout the text add some specific ideas to the fairly generalized recommendations in the report.

Berkeley, California. Climate Action Plan Indicators. City of Berkeley, CA. www.cityofberkeley.info/climate/

This website is a good example for implementation. It is set up to provide information on the goals of the city's sustainability plan and has links to pages that show annual progress toward the those goals. It would be useful for explaining transparency and benchmarking.

Center for Science in the Earth System (The Climate Impacts Group), King County, Washington, and ICLEI Local Governments for Sustainability. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments.* www.cses.washington.edu/db/pdf/snoveretalgb574.pdf

Practical information on why and how governing bodies can prepare for climate change. This includes ideas about how to build public support, how to collect necessary data, do vulnerability assessments, evaluate tools, establish benchmarks and measure progress.

Chicago Climate Plan. www.chicagoclimateaction.org/

Chicago's plan is one of the best city plans currently available. It has clear data about how climate change will affect the city, describes what the city is doing, and provides suggestions for actions that can be taken by residents and businesses in the city.

Dinse, K., J. Read, and D. Scavia. (2009). *Preparing for Climate Change in the Great Lakes Region.* [MICHU 09-103] Ann Arbor, MI: Michigan Sea Grant. www.miseagrant.umich.edu/downloads/climate/Climate_Workshop_Report.pdf

A workshop among 40 representatives of Great lakes foundations, NGOs, agencies, and universities was held in Flint, MI, to focus on "Preparing for Climate Change in the Great Lakes Region." The participants focused on: 1) policy changes that would allow communities to adapt to climate change and protect ecosystems and 2) strategies for implementing those policy changes. This report summarizes their ideas and gives additional background to support their recommendations.

Folke, C (2006). "Resilience: the emergence of a perspective for social–ecological systems analyses." *Global Environmental Change* 16 (3), pp. 253–267
Abstract: The resilience perspective is increasingly used as an approach for understanding the dynamics of social-ecological systems. This article presents the origin of the resilience perspective and provides an overview of its development to date. With roots in one branch of ecology and the discovery of multiple basins of attraction in ecosystems in the 1960-1970s, it inspired social and environmental scientists to challenge the dominant stable equilibrium view. The resilience approach emphasizes non-linear dynamics, thresholds, uncertainty and surprise, how periods of gradual change interplay with periods of rapid change and how such dynamics interact across temporal and spatial scales. The history was dominated by empirical observations of ecosystem dynamics interpreted in mathematical models, developing into the adaptive management approach for responding to ecosystem change. Serious attempts to integrate the social dimension are currently taking place in resilience work reflected in the large numbers of sciences involved in explorative studies and new discoveries of linked social-ecological systems. Recent advances include understanding of social processes like, social learning and social memory, mental models and knowledge-system integration, visioning and scenario building, leadership, agents and actor

groups, social networks, institutional and organizational inertia and change, adaptive capacity, transformability and systems of adaptive governance that allow for management of essential ecosystem services.

NACo. *The Five Star Restoration Program*. www.naco.org/Template.cfm?Section=Environment,_Energy_and_Land_Use&template=/ContentManagement/ContentDisplay.cfm&ContentID=29759

The program seeks to develop community capacity to sustain local natural resources for future generations by providing modest financial assistance to diverse local partnerships for wetland, riparian, and coastal habitat restoration. This is an example of a program with a clear list of requirements and measurements.

Sea Grant, University of Minnesota. *Implementation Plan 2010–2013*. www.seagrant.umn.edu/downloads/mnsg_implePlan10-13_final.pdf

This plan is a good example of how to set short and long-term goals that are allow for assessing achievements. Each topic has Expected Short-term Outcomes, Expected Long-Term Outcomes, and Measurable Objectives that include information about what will be measured, how and by when. Although the plan is specific to the needs of Minnesota, many of the goals will be similar in other Great Lakes states.

Wondolleck, Julia M. and Steven L. Yaffee (2000). *Making Collaboration Work: Lessons from Innovation in Natural Resource Management*. Washington DC: Island Press

The authors pull together case studies of diverse collaboration efforts and use these real-world examples to explore what attributes make collaboration a successful strategy for natural resource management. They discuss issues of institutional organization, human interactions, accountability and implementation. They also highlight types of situations for which collaboration is appropriate, common barriers that may arise, and potential solutions to help overcome these challenges. The criteria for successful processes described here are equally applicable to collaborative planning processes and would work well for Adaptation Planning.

Scientific Uncertainty and Climate Change Communication

Ascher, W. 2004. Scientific information and uncertainty: challenges for the use of science in policymaking. *Science and Engineering Ethics*. 10(3):437-455.

Science can act as part of the policy process. It can help to counter policies that are not supportive of public interests. Motives of specialized groups pose a threat of suppression, over-simplification and distortion of scientific information. Scientists must learn how to communicate uncertainty in understanding and prediction to prevent 'no action' and attempts to discredit scientific findings.

Babrow, A.S. 2001. Uncertainty, value, communication and problematic integration. *Journal of Communication September* 2001:553-73.

Problematic Integration (PI) Theory provides a perspective on the dynamic interactions between communication science, expectations and desires. The paper examines theory with an analysis of uncertainty and tensions among wants and wishes.

Ban, R.J. et al. ed. 2006. Completing the Forecast- Characterizing and Communicating Uncertainty for Better decisions Using Weather and Climate Forecasts. National Research Council. Available online at www.nap.edu.

Communicating uncertainty is inherent in weather forecasting. The report discusses uncertainty in decision making, estimating and validating uncertainty, communicating forecast uncertainty and overarching recommendations.

Berk, R. A. et al., 1995. Public perceptions of global warming. *Climatic Change* 29(1):1-33.

The paper focuses on the public's understanding and willingness to pay to prevent climate change. A survey was conducted in Southern California that shows the public was able to understand and evaluate complicated hypothetical climate scenarios. The public appreciated some climate features greater than others.

Berk, R. A. et al. 2001. The use of statistical tools for evaluating computer simulations. National Science Foundation no citation

The quality of model simulations is crucial to the quality of science. Beyond using modeling assessment tools, many climate scientists fail to use a number of statistical procedures as part of an overarching evaluation strategy. Also, assessment efforts often lack formal justification. Modelers should use a general strategy for evaluation embedded in epistemology and modern statistics, while using assessment tools as part of that strategy – not the entire evaluation.

Berliner, M. 2003. Uncertainty and climate change. *Statistical Science* 18(4):430-35

The article reviews the basic arguments around anthropogenic climate change with an emphasis on uncertainty.

Bord, R.J. et al. 2000. In what sense does the public need to understand global climate change? *Public Understanding of Science* 2000: 205-218

A survey of 1,218 Americans found that a correct understanding of the causes of climate change are a key factor in behavioral intentions – taking voluntary actions and voting on new government policies to reduce greenhouse gases. Gaining information about bogus causes of climate change correlated with a belief that the globe will warm and voluntary actions. Bogus information was not related with supporting government policies. Pro-environmental beliefs that climate change causes a serious threat helped explain behavioral intentions as well. Negative effects on air pollution and general environmental concern did not translate to support for programs to control climate change.

Bostrom A. et al. 2008. Visualizing seismic risk and uncertainty: a review of related research. Ann. NY *Acad. Science* 1128:29-40.

Earthquake risk is commonly communicated though maps using geographic information systems. Research has been done to communicate risk in a text format, but a similar guidance in not available for visual communication mediums. Some study has been done for map design, spatial and visual perception as well as graphs. The paper outlines early research that may be useful in communicating spatial and visual information.

Bostrom, A et al. 1994. What do people know about global climate change? 1. Mental Models. *Risk Analysis* 14, 959–970.

Exploratory studies and interviews were conducted to gain insights about public understanding of climate change. Respondents regarded climate change as bad and highly likely and many believed it has already occurred. The science behind climate change was often misunderstood and mitigation efforts tended to focus on pollution control strategies with few linkages to carbon dioxide and energy use.

Brashers, D.E. Communication and uncertainty management. *Journal of Communication* Sep 2001 477-97

To communicate uncertainty, anxiety surrounding uncertainty needs to be removed. To better answer questions regarding uncertainty, certain questions should be answered 1) the experience and meaning of uncertainty 2) the role of appraisal and emotion in uncertainty management 3) and the range of behavioral and psychological responses to uncertainty. The paper discusses a theory of uncertainty management and reviews current theories in this area while also applying the information to health communication.

Bray, D. et al. 1999. Climate science: an empirical example of post-normal science Bulletin of the American Meteorological Society Vol. 80, No. 3, March 1999

A survey questionnaire mailed to 1,000 scientists around the world with a response rate of 40 percent shows insights into views regarding certainty and uncertainty of climate science. While some discourse is present among countries,

there was consensus that climate science has proven enough knowledge to initiate abatement measures. There was also consensus that there is an inability to specify detrimental effects of climate change.

Cairns, J. 2003. Interrelationships between the precautionary principle, prediction strategies, and sustainable use of the planet. *Environmental Health Perspectives* 111(7):877-80.

The article examines human activity in the environment and prevention strategies used for sustainable management of the environment. The author argues that industrial ecology and natural capitalism go beyond preventing environmental damage to optimization. Additional tools are needed to form a holistic, scientific approach to human and environmental interactions.

Collins, M. 2007. Ensembles and probabilities: a new era in the prediction of climate change. *Phil. Trans. R. Society A* 365: 1957-70

Corbett, J.B. et al. 2004. Testing public (un)certainty of science: media representations of global warming. *Science Communication* 26:129-51

An exploratory study examined the role of new stories in a reader's assessments of certainty in scientific findings. The study tested whether adding controversy and/or context to a new story about climate change affected perceptions of certainty.

Durant, J. R. et al 1989. The public understanding of science. *Nature* 340 (6 July 1989): 11–14.

Eckblad, G. 1963. The attractiveness of uncertainty. *Scandinavian Journal of Psychology* 4:1-13

The attractiveness of uncertainty and problem solving tasks of different information content was presented to a sample group. An inverted U-shaped relationship between uncertainty and attractiveness of the situation was supported.

Ellison, A. M. 2004. Bayesian inference in ecology. *Ecology Letters* 7: 509-20

The paper discusses Bayesian inference as an important statistical tool that is being used by ecologists. Not all ecologists appreciate the philosophical underpinnings of Bayesian inference. Assumptions should be explicitly addressed before choosing to use this method to analyze data.

Frame, D.J. et al. 2007. Probabilistic climate forecasts and inductive problems. *Phil. Trans. R. Soc. A.* 365:1971-1992

Ensemble-based 'probabilistic' climate forecasts pose opportunities and challenges in helping scientists develop forecasts. This process allows the report to reflect uncertainty from varied sources. The paper discusses approaches and attempts to develop complex model experiments.

Friday, E.W. et al. 2003. Communicating Uncertainties in Weather and Climate Information; a Workshop Summary. *National Academy of Science* 2003. Available online at www.nap.edu

The paper outlines several case studies and discusses the lessons learned from each study pertaining to effectively communicating uncertainties in weather and climate.

Funtowicz, S. et al. 1997. Environmental problems, post-normal science and extended peer communities. *Etudies Recherche Syst. Agrarire.* Dec. 30: 169-75.

Funtowicz et al. 1994. Uncertainty, complexity and post-normal science. *Environmental Toxicology and Chemistry* 13(12):1881-85.

Garrett, J.M et al. 2004. Ethical issues in communicating science. *Public Understand. Science*. 13 (2004) 295–308

Goldsmith, D.J. 2001. A normative approach to the study of uncertainty and communication. *Journal of Communication September* 2001:514-32.

The essay conveys an alternative to uncertainty reduction theory. It addresses not only measuring levels of uncertainty, but examining different meanings of uncertainty.

Gross, P.R. 2009. Learning science: content-with reason. *American Educator* 33 35-40.

The article discusses the debate on whether to focus on scientific content or scientific reasoning in science education. The author argues that both content and reasoning are essential.

Grubler, A., et al. . (2001). Identifying dangers in an uncertain climate. *Nature*, 412, 15.

Groves, D.G. 2007. A new analytic method for finding policy-relevant scenarios. *Global Environmental Change* 17 (2007) 73–85

The paper describes an analytical method for narrative scenarios that emerge from decision making. This is done by developing statistical analysis of datasets by computer simulation models. The scenario can therefore, with analysis, communicate quantitative judgments about uncertainty and support decision-making. The method is used in a case-study of long-term water panning in California.

Haag, D. et al. 2001. Parameters, prediction, post-normal science and the precautionary principle – a roadmap for modeling for decision-making. *Ecological Modeling* 144: 45-60.

Handmer, J. Et al. 2007. Communicating uncertainty via probabilities: the case of weather forecasts. *Environmental Hazards* 7: 79-87

Daily weather forecasts are used to analyze alternatives to communicating uncertainty. Probabilities are used for daily events in this context. If people do not understand a short-term event like the weather, it is unlikely people will understand unfamiliar events using unfamiliar language. The paper examines public understanding of probabilities and verbal categorical forecast terms using multiple sources, including a survey. The surveys indicated a basic understanding of probabilities by the majority of people. Other findings indicate that forecasters were not in agreement about the meaning of probabilistic statements.

Ibrekk, H. et al. 1987. Graphical communication of uncertain quantities to Non-technical people. *Risk Analysis*, Vol. 7. No. 4, 1987

Nine pictorial displays for communicating quantitative information about the value of an uncertain quantity, **x,** were evaluated for their ability to communicate $\boldsymbol{2, p(x} > a)$ and $\boldsymbol{p(b} > \mathbf{x} > a)$ to well-educated semi- and nontechnical subjects. Different displays performed best in different applications. The authors recommend the use of a cumulative distribution function plotted directly above a probability density function with the same horizontal scale, and with the location of the mean clearly marked **on** both curves. (Ibrekk)

Karl. T.R. et al. 2003. Modern global climate change. *Science* 302(5651):1719-23.

Human-induced changes in atmospheric conditions are the largest source of climate change. Athough there is progress in monitoring and understanding climate change, there is still scientific, technical and institutional questions that affect adaptation and mitigation plans. Uncertainty still remains on what can be expected in the climate realm.

Keeney, R.L. 1982. Decision analysis: an overview. *Operations Research*. 30(5): 803-838.

Kloprogge, P. et al. 2007. Uncertainty communication: issues and good practice. Copernicus Institute for Sustainable Development and Innovation. 60p.

The report contains background information on communicating uncertainty, an analysis of context and audiences, customizing communication accordingly as well as practical suggestions on reporting uncertainty information.

Knutti, R. (2008) Should we believe model predictions of future climate change? *Philosophical Transactions of the Royal Society*, Series A,

Computer models play a significant role in predicting future climate. The paper discusses evaluation of these models, what makes scientists confident in these models, how uncertainty predictions can be quantified and why models tend to focus on observations, rather than predictions. Suggestions are given for how modelers overcome obstacles and can improve information to the public and policy-makers.

Knutti, R. et al. 2002. Constraints on radiative forcing and future climate change from observations and climate model ensembles. *Nature* 416 April 2002: 719-23

The paper presents probabilistic climate projections using a simpler climate model. The uncertainties created by the model and in poorly quantified parameters are accounted for. Simulations of two emission scenarios suggest a 40 percent probability that global-mean surface temperature increase will exceed IPCC predictions but only a 5 percent probability that it will fall below that range.

Krynski, T.R. 2007. The role of causality in judgment under uncertainty. *Journal of Experimental Psychology*: 2007, Vol. 136, No. 3, 430–450

Lahsen, M. 2005. Seductive simulations? Uncertainty distribution around climate models. *Social Studies of Science* 35(6):895-922.

This paper discusses the distribution of certainty around General Circulation Models (GCMs) which are computer models used to project possible global climatic changes due to human emissions of greenhouse gases. It examines the 'certainty trough', and calls for a more multi-dimensional and dynamic conceptualization of how uncertainty is distributed around technology.

Lempert, R., et al. 2004. Characterizing climate-change uncertainties for decision-makers. *Climatic Change* 65, 1–9.

Locke, S. 1999. Golem science and the public understanding of science: from deficit to dilemma. *Public Understand. Sci*. 8 (1999) 75–92.

The paper provides a 'flip-flop' argument for 'golem science' and argues that distrust between the public and scientists are an outcome of a deeper problem within science between status of knowledge claims and human conditions of knowledge production.

Manning M.R. 2003. The difficulty of communicating uncertainty. *Climatic Change* 61:9-16.

The uncertainty around climate change is not unique to other scientific areas. Uncertainty poses challenges for decision makers in many scientific issues. Climate change is unique in that it is something that people can relate to but the root of the causes may not be as inherent. The paper discusses the challenges of communicating climate change to a broader community.

McCann. R.K. et al. 2006. Bayesian belief networks: applications in ecology and natural resource management. *Canadian Journal of Forestry Research* 36: 3053-62

Minnegal, M. et al. 2008. Fire, flood, fish and the uncertainty paradox. *Australian Journal of Anthropology* 77-81.

In an attempt to sustain natural resource systems through attention to uncertainties, scientists and managers may unknowingly create an experience of uncertainty that has negative consequences to the physical and mental health of individuals and communities that are dependent on these resources. The authors also challenge the ability of scientists to model projections of the future.

Morgan, M. G., et al. 1995: Subjective judgments by climate experts. *Environ. Sci. Technol*., 29, 468A–476A.

Moser, S.C. et al. (2004) Making climate hot: communicating the urgency and challenge of global climate change," *Environment* 46(10): 32–46.

Murphy, A.H. 1991. Probabilities, odds and forecasts of rare events. *Weather and Forecasting*. June 1991:302-307.

There are several issues surrounding the forecasts of rare and severe events. Issues include the relationship between forecasters' judgments and forecasts, over-forecasting, and the use of forecasts for rational decision making. The author argues that current practices are not sufficient and the paper discusses this issue.

Murphy, A.H. et al. 1980. Misinterpretation of precipitation probability events. *Bulletin of the American Meteorological Society* 61, 695-701, 1980.

A questionnaire was given to residents of Eugene, Oregon designed to gather information about peoples understanding of and attitude towards probability forecasts. Results indicate that the event in question is often misunderstood and most residents had a preference for the use of probabilities to express uncertainty. This counters the argument that people do not understand probabilities.

Murphy, A.H. et al. 1979. Probabilistic temperature forecasts: the case for an operational program. *Bulletin of the American Meteorological Society* 60, 12-19.

The paper presents a case for an operational program that involves the formulation and dissemination of probabilistic temperature forecasts. The essential components for this program are outlined and suggestions are made for specific temperature events that should receive probabilistic treatment.

Murphy, A.H. et al. 1971. Forecasters and probability forecasts, the responses to a questionnaire. *Bulletin of the American Meteorological Society* 52, 58-64.

The paper offers a summary of findings from a questionnaire given to forecasters of the Travelers Weather Service regarding probability forecasting. The responses suggest a number of issues related to probability forecasting.

Murphy, A.H. et al. 1971 Forecasters and probabilities: some current problems. *Bulletin of the American Meteorological Society* 52, 239-248

The paper outlines some current issues around probability forecasting outlined from the Travelers Weather Service questionnaire. The paper describes the nature of the problem, and indicates approaches and results which clarify issues and make recommendations. The formulation of judgments in the assessment process, interpretation of probability forecasts, occurrence of 'hedging' forecasters and evaluation of probability forecasts is all addresses.

Oppenheimer, M. et al. 2006. Global warming: the psychology of long term risk. *Climatic Change* 77:1-6

Parry M. 2002. Scenarios for climate impact and adaptation assessment. *Global Environmental Change* 12: 149-53.

Patt, A. et al. 2005. Communicating uncertainty: lessons learned and suggestions for climate change assessment. C.R. *Geoscience* 337 (2005):425-41

The IPCC has developed an approach to overcoming the challenges of communicating uncertainty. Based on a survey of climate change experts, this paper evaluates the success of this approach. Findings suggest that the approach provided by the IPCC leaves the possibility for biased and inconsistent responses to information. Suggestions for future reports are provided.

Pinch, T. 2000. The golem: uncertainty and communicating science. *Science and Engineering Ethics* 6: 511-23.

Popper, S.W., et al. 2005. Shaping the future. *Scientific American* 292 (4), 66–71.

Powell, M. et al. 2007. Exploring lay uncertainty about environmental health risk. *Public Understanding of Science*; 16: 323-43

This study explores how people perceive uncertainties regarding environmental health risks, how risk-related emotions and condition affect these uncertainties and what roles socio-demographic, risk judgments, context and exposure play to information. Results suggest that emotions are strongly associated with perceived uncertainty while the perceived lack of knowledge and the perceived likelihood of becoming ill are weakly correlated. Findings indicate that these are complex interactions that raise further questions about how all these factors are interrelated.

Ravetz, J.R. 2006. Post-normal science and the complexity of transitions towards sustainability. *Ecological Complexity* 3:275-284.

Post-Normal Science should be renewed and enriched. A theory of complex systems is proposed, establishing a review of the methodology of science in the policy process.

Ravetz, J.R. 2004. The post-normal science of precaution. *Futures* 347-357.

Two sorts of science can be distinguished from one another – 'mainstream', reductionist style that is linked to industry and the 'post-normal' approach. The post-normal approach depends on public debate and is essential for communication beyond the peer community. The traditional problem-solving approach to science is not adequate when system uncertainties and decision making stakes are high. A new form of science is necessary for these types of issues.

Ravetz, J. R. 1999. What is post normal science?. *Futures*, *31*, 7, 647-653.

Regen, H.M. et al. 2002. A taxonomy and treatment of uncertainty for ecology and conservation biology. *Ecological Applications* 12(2): 618-28.

Rowe, W.D. 1994. Understanding uncertainty. *Risk Analysis* 14(5): 743-750.
A framework for classification of different types of uncertainties is provided. Uncertainty and variability are structured in four classes: metrical uncertainty and variability in measurement, structural uncertainty due to complexity, including models and their validation, temporal uncertainty in future and past states and translational uncertainty in explaining uncertain results.

Read, D., et al. 1994. What do people know about global climate change? 2. survey studies of educated laypeople. *Risk Analysis* 14, 971–982.
A survey, developed based on earlier open-ended interviews, examines public knowledge about possible causes of climate change and likely efficacy of possible interventions. Results indicate that people have poor appreciation for the role of fossil fuels in climate change and that if significant climate change occurs it will primarily be the result of an increase in concentration of carbon dioxide in the earth's atmosphere.

Reilly, J., et al. 2001. Uncertainty and climate change assessments. *Science* 293, 430–433.
The assessment of uncertainty provided by the IPCC should be improved by using a consistent approach to quantifying uncertainty - focusing on quantifying a few key results for policymakers. Procedure for this quantification should be documented as well as experts consulted.

Rubino, C.A. The politics of certainty: conceptions of science in an age of uncertainty. *Science and Engineering Ethics* 6:499-508.
The paper discusses our ability to predict events in a limited sphere. Some scientists cling to the ideal of certainty, which the author claims has had adverse effects on humanities and has created illusions regarding a sense of power. Some scientists emphasize the creative power of spontaneity, novelty and surprise.

Saloranta, T. M. 2001. Post-normal science and the global climate change issue. *Climatic Change* 50, 395–404.
The science community has been given the increased challenge of making science policy-relevant. The concept of Post-Normal' science is introduced and addressed using the climate change challenge. The author argues that climate science of the IPCC may be classified as Post-Normal.

Scheffer, M., et al. . 2001. Catastrophic shifts in ecosystems. *Nature* 413, 591–596.

The paper provides reasoning for focusing sustainable management of ecosystems on resilience.

Schneider, S.H., 2006. Climate change: do we know enough for policy action? *Science and Engineering Ethics* (2006) 12, 607-636

The climate change challenge should be addressed in the context of risk management policy along with other scientific research. Policymakers have a role of taking the information and determining value judgments. Probabilities are important to making these judgments. The author argues that the climate debate needs to move away from absolute costs/benefits into relative delay times to achieve specific caps or avoid dangerous climate temperature thresholds.

Schneider, S.H., 2001. What is ‘dangerous’ climate change? *Nature* 411, 17–19.

The paper identifies the science of climate change and the IPCC assessments on emissions scenarios and impacts. The concept of 'dangerous' climate change is discussed along with the role of scientists and policymakers in this area.

Schneider, S.H. 1993. Degrees of certainty. *National Geographic Research and Exploration* 92(2) 173-190

Schneider, S.H., et a.l. 1998. Imaginable surprise in global change science. *Journal of Risk Res*. 1, 165–185.

Decision makers from multiple realms are concerned with reducing vulnerability to unexpected events due to climate change. The definition of 'surprise' outlined in the paper does not apply to a wholly unexpected outcome, but recognizes that events are observed or anticipated by viewers. This is dependent on community expectations and salience of the problem. 'Imaginable surprise' departs from expectations of a community. Based on scholarly input, two tables of possible definitions are provided of 'imaginable surprises' in the context of climate change.

Schneider, S.H. 2002. Editorial Comment: Can we estimate the likelihood of climatic changes at 2100? *Climatic Change* 52, 441–451.

Skinner, L, 2008. Facing future climate change: is the past relevant? *Phil Trans. R. Soc.* A 2008 366, 4627-4645

The paper argues that our approach to climate change is greatly linked to the past, due in large part to palaeoclimate reconstructions in shaping future predictions and expectations. Models in our minds and supercomputers also intuitively carry this link. Through these models, Palaeoclimate insights affect scientific and political judgments. Climate models should take advantage of past and present constraints and should be accompanied by clearly defined uncertainties and organized in a way that speaks directly to numerical models and their limitations.

Slovic, P. 1998: The risk game. *Reliability Engineering and System Safety* 59:73-77

Risk management has received attention and funding as government and industry work to meet the demand from the public for a cleaner environment. Although these efforts are increasing, the public has become less concerned about risk. The author proposes a new perspective on risk and discusses the role of risk in agenda setting.

Stainforth, D. A. et al. 2005 Uncertainty in predictions of the climate response to rising levels of greenhouse gases. *Nature* 433, 403–406.

When planning mitigation and adaptation, a full range of possibilities of climate needs to be discussed. This paper presents results from the 'climateprediction.net' experiment which is the first multi-thousand-member grand ensemble of simulations. These models are as realistic as other versions with greater climate sensitivities which are crucial for studying the full range of climate change responses.

Stainforth, D. A. et al. . 2007 Confidence, uncertainty and decision-support relevance in climate predictions. *Phil. Trans. R. Soc.* A 365, 2145–2161.

Climate models are core tools in studying the interactions of climatic processes and provide additional arguments regarding anthropogenic warming. The author argues that it is inappropriate to use climate models in forecasting future climate predictions because these models being used have never before been experienced by the system. The article discusses where confidence is derived from climate forecasts and presents concepts for communication.

Stainforth, D.A. et al. 2007. Issues in the interpretation of climate model ensembles to inform decisions. *Phil. Trans. R. Soc.* A 365, 21163-77.

Adaptation and mitigation require action on various scales. Adaptation could benefit from regional climate predictions, while mitigation could be driven based on global issues. The paper discusses development of climate model simulations that can be interpreted on these different scales to inform decisonmaking. The paper also discusses how these models can be interpreted and therefore provide one input for decision making.

Stendel, M. et al. 2000. Assessing levels of uncertainty in recent temperature time series. *Climate Dynamics* 16: 587-601.

The paper examines the degree in which accurate temperature trends can be expected for the last decades near the surface and lower troposphere.

Stott, P.A. et al 2002. Origins and estimates of uncertainty in predictions of twenty-first century temperature rise. *Nature* 416 April 2002:723-

The paper shows the relative importance of uncertainty in climate response to a particular emissions scenario. Four scenarios for future emissions are presented with probable forecasts of global-mean temperatures. In absence of policies to mitigate climate change, global-mean temperature rise is insensitive to the difference in the four emissions scenarios.

Sturgis, P. et al. 2004. Science in society: re-evaluating the deficit model of public attitudes. *Public Understanding of Science* 13(1): 55–74.

The paper challenges the “deficit model” of public attitudes towards science. The connection between this model and contextualist perspectives is tested. The results indicate an importance of knowledge as a determinant of attitudes toward science. The complex nature of knowledge is also addressed.

Sunstein, C. 2006. On the divergent reactions to global terrorism and climate change *Columbia Law Review* Vol. 107:503-557

The paper discusses risk perception and the public demand for legislation by contrasting America's war on terrorism with the climate change challenge. The author argues that this discrepancy between reacting to both issues is due to bounded rationality. Also, two conditions are likely to be met before American's support significant steps to combat climate change 1) costs are perceived to be low 2) new information or incident indicates that Americans have much to gain from risk reduction.

Thompson, K. M. 2002. Variability and uncertainty meet risk management and risk communication. *Risk Analysis* 22(3):647-53

The paper discusses the challenges in risk communication. There is a shift away from the use of point estimates to the use of distributions in decision making. The use of case studies explore variability and demonstrates that probabilistic risk assessment has an impact on risk management and communication.

Tversky, A., et al. 1974. Judgment under uncertainty: heuristics and biases. *Science* 185 (4157):1124-31.

The article discusses heuristics that are used in making judgments about uncertainty. Heuristics should be better understood to aid in improving judgments and decisions based around uncertainty. The three heuristics used in making judgments under uncertainty include, 1) representativeness 2) availability of instances or scenarios 3) adjustment from an anchor.

Van der Sluijs, J.P. et al. 2003. RIVM/MNP Guidance for Uncertainty Assessment and Communication: Detailed Guidance. Copernicus Institute for Sustainable Development and Innovation. 65p.

The report provides an introduction as well as detailed guidance for uncertainty and communication in environmental assessments. Problem framing and context, process assessment, environmental assessment methods, uncertainty identification and prioritization, uncertainty analysis, review and evaluation and reporting are all addressed.

Walker, W.E. 2000. Uncertainty: the challenge for policy analysis in the 21st century. Lecture presented in 2000 at the Delft University of technology. Rand Corporation website: www.rand.org

The author suggests that a new policymaking paradigm and new tools for performing policy analysis is needed that will help dealing with uncertainties. The paradigm, adaptive policymaking, allows for flexible response to changing circumstances and allows for learning over time.

Weber, E.U. 2006. Experience-based and description-based perceptions of long-term risk: why global warming doesn't scare us yet? *Climatic Change* 77:103-20.

Weber, J.R. et al. 2001. The communication process as evaluative context: what do nonscientists hear when scientists speak? *BioScience* 51(6):487-95.

The article marks a third necessary activity in science – informing the general public of the relevance and importance of the work. The authors argue that ecologists of the future should be trained in teaching the public about ecological services and losses in biodiversity.

Wynne, B. 1992. Misunderstood misunderstandings: social identities and public uptake of science. *Public Understanding of Science* 1: 281–304.

Yearley, S. 2000. Making systematic sense of public discontents with expert knowledge: two analytical approaches and a case study. *Public Understanding of Science* 9: 105-22.

Local knowledge has proven to be more sensitive to local situations than many expert opinions. Recent case studies have shown that local knowledge is not inferior, although historically less valued than expert opinion. In addition to case studies, two conceptual schemas for understanding this topic are explored.

Regional, State and Local Climate Policies

STATE CLIMATE POLICIES

Illinois
Illinois Climate Change Advisory Group: Final Recommendations to the Governor (Approved July 10 and September 6, 2007)
Includes recommendations for transport; power/energy; cap and trade; and commercial, industrial, and agriculture (CIA).
http://www.epa.state.il.us/air/climatechange/documents/final-recommendations

Executive Order 2006-11: Announced Illinois' membership in the Chicago Climate Exchange (CCX), and pledged to reduce GHG emissions from governmental activities by 2010.
http://www.illinois.gov/Gov/pdfdocs/execorder2006-11.pdf

On February 13, 2007, Governor Blagojevich announced new statewide GHG emission reduction targets of 1990 levels by 2020 and 60 percent below 1990 levels by 2050.
http://illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=2&RecNum=5715

Chicago Climate Action Plan

Chicago's 2008 Climate Action Plan proposes actions to achieve a GHG emissions reduction of 80 percent below 1990 levels by 2050 with an interim goal of 25 percent below 1990 levels by 2020. The plan outlines 35 actions in five categories related to energy efficient buildings, clean energy, transportation, waste, and adaptation.
Future Initiatives include: Building Retrofits; One-Stop-Shop; Energy Efficiency Code; Global Building Monitoring System; Green Office Challenge; Solar Energy; Transit Oriented Development; Improved Transit Fare Cards; Carbon Offset Fund; Climate Action Plan Jobs; Extreme Heat; Extreme Precipitation; Ecosystem Changes; and Building, Infrastructure and Equipment Integrity.
Link: http://www.chicagoclimateaction.org/

Indiana
No Climate Action Plan
Observer to Midwestern Regional Greenhouse Gas Reduction Accord
Member of Lake Michigan Air Directors Consortium (LADCO) Regional GHG Registry

Michigan

Michigan Climate Action Council's Climate Action Plan, March 2009
http://www.miclimatechange.us/ewebeditpro/items/O46F21226

Executive Directive 2009-4, July 2009

Michigan Governor Granholm issued Executive Directive 2009-4, which sets a goal to reduce the state's greenhouse gas (GHG) emissions to 20 percent below 2005 levels by 2025 and 80 percent below 2005 by 2050. The Directive also implements policy measures to achieve these GHG emission reductions. The goal and the policy measures are products of the Michigan Climate Action Council (MCAC) commissioned by Governor Granholm to develop a climate action plan for the state. The policy measures within the Executive Directive include agricultural education programs aimed at teaching farmers practices that enhance biological carbon sequestration; building code revisions designed to improve energy efficiency; state and local plans to alleviate vehicular congestion and improve the efficiency of transport; and the development of a program that will curb state vehicle idling times.

The MCAC was created by executive order in November of 2007 and consisted of over 100 stakeholders including business, labor, environmental, forestry, agricultural, and academic interests. The MCAC delivered 54 policy recommendations in March of 2009, 52 of which were unanimously recommended by all MCAC participants. An MCAC-approved economic analysis of 35 of these recommendations concludes that their implementation will save the state $10 billion by 2020 while reducing emissions to 10 percent below 1990 levels.
http://www.michigan.gov/gov/0,1607,7-168-36898-219081--,00.html

Minnesota

Minnesota Climate Change Advisory Group Final Report: A Report to the Minnesota Legislature, April 2008

The MCCAG approved 46 recommendations to reduce emissions, of which 31 were analyzed quantitatively to estimate their effects on emissions and 25 were analyzed quantitatively to estimate their costs/cost savings. The analyzed measures were estimated to have a cumulative effect of reducing emissions by about 22 MMtCO2e in 2015 and 50 MMtCO2e in 2025. Together, the estimated emission reductions associated with the MCCAG's recommendations and recent actions would be enough to achieve Minnesota's GHG reduction goal for 2015 and be within 2.4 MMtCO2e of meeting Minnesota's goal for 2025. The 25

recommendations analyzed in terms of their cost-effectiveness were estimated to have a total net cost of about $726 million between now and 2025, representing the incremental cost to the recent actions. While the MCCAG's 15 other recommendations were not readily quantifiable, many of them would likely achieve additional reductions and net savings (e.g., recommendations for the Transportation and Land Use [TLU] sector). Should Minnesota implement the MCCAG's recommendations to participate in a cap-and-trade program, opportunities exist for reducing the costs associated with the MCCAG's policy recommendations for the electricity supply sector. In addition, emerging technologies may hold the potential to substantially reduce emissions even more.
Link: http://www.mnclimatechange.us/MCCAG.cfm

Next Generation Energy Act

On May 25, 2007, Minnesota Governor Tim Pawlenty signed into law the Next Generation Energy Act, which established statewide GHG emission reduction goals of 15 percent by 2015, 30 percent by 2025, and 80 percent by 2050, based on 2005 levels.

The Next Generation Energy Act also includes requirements for Minnesotans to increase energy efficiency and expand community-based energy development. The state law also supplements the aggressive 25x'25 renewable energy standard signed by the Governor.

Link:
https://www.revisor.mn.gov/bin/bldbill.php?bill=S0145.2.html&session=ls85

Duluth Climate Action Plan

In May 2001, the City of Duluth joined the Cities for Climate Protection Campaign, which is coordinated by the International Council for Local Environmental Initiatives (ICLEI). Duluth pledged to:

- Take a leadership role in increasing energy efficiency and reducing greenhouse gas emissions from municipal operations;
- Develop and implement a local action plan, which describes the steps to reduce both greenhouse gas and air pollution emissions. The plan will include:

(1) A greenhouse gas emissions analysis and forecast to determine the source and quantity of greenhouse gas emissions within the jurisdiction;

(2) A carbon dioxide or greenhouse gas emissions reduction target;

(3) The strategy for meeting Duluth's greenhouse gas reduction target, including
an outline of the programs and measures that will be implemented to achieve the target.

Link: http://www.pca.state.mn.us/publications/reports/mnclimate-action-plan.pdf

Current status of Duluth climate action plan/goals:
* GHG inventory complete.
* Community-based steering committee and city department committee formed.
* Plans to install 3 renewable energy systems and accompanying educational displays at the Lake Superior Zoo.
* Replacement of all incandescent red and green traffic signals with more efficient LED signals will save over $68,000/yr.in energy costs.
* $20,000 grant received through the Rebuild MN program to install a 2.4 kW PV system on the Duluth Public Library.
* Four buildings examined by MN WasteWise will be used as models for good practices in waste reduction and energy conservation.
Link: http://www.ci.duluth.mn.us/city/information/ccp/index.htm

Minnesota Climate Change Action Plan: A Framework for Climate Change Action
Minnesota Pollution Control Agency, February 2003
http://www.pca.state.mn.us/publications/reports/mnclimate-action-plan.pdf

New York
Recommendations to Governor Pataki for Reducing New York State Greenhouse Gas Emissions, The Center for Clean Air Policy, April 2003
http://www.ccap.org/docs/resources/534/NYGHG_Report.pdf

Office of Climate Change, Department of Environmental Conservation
The office is organized into two bureaus:
Climate Science and Technology: uses sound science, engineering and economic principles to design solutions that will help stabilize atmospheric greenhouse gas concentrations at acceptable levels; supports the development of climate impact analyses to help New York respond to the impacts of climate change; contributes to state energy and climate planning.
Climate Programs and Partnerships: works to inform, assist and empower state agencies, local governments, NGOs, institutions, businesses and individuals as they reduce carbon emissions and adapt to unavoidable impacts.
The Office also promotes voluntary emissions reporting by New York facilities through the national Climate Registry.
Link to the Office of Climate Change website:
http://www.dec.ny.gov/about/43166.html

Member of the Regional Greenhouse Gas Initiative (RGGI)

New York is one of ten Northeastern and Mid-Atlantic states who are members of this Regional Initiative. These states participate in a cap-and-trade program and are required to reduce their C02 emissions from the power sector 10% by 2018. States sell nearly all emission allowances through auctions and invest proceeds in consumer benefits: energy efficiency, renewable energy, and other clean energy technologies.
Link to the RGGI website: http://www.rggi.org/home

Ohio
No climate change action plan.
Observer to the Midwestern Regional Greenhouse Gas Reduction Accord

Pennsylvania
Climate Change Action Plan (2009)

The action plan calls for a 30% reduction in GHG emissions below 2000 levels by 2020. The action plan identifies 52 specific work plans (recommendations) as well as several recent actions taken by Pennsylvania and the federal government that combined will provide GHG emissions reductions in Pennsylvania of 42 percent below 2000 levels in the year 2020. The 52 recommendations of this report, on their own, are anticipated to yield a 36 percent reduction in emissions by 2020.
http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-77736/ALL%20OF%20VOLUME%201%20AND%202.pdf

Pennsylvania Climate Change Act (2008)

The law creates a voluntary greenhouse gas registry for businesses to track their emissions and receive credits for reductions. It also calls for an inventory of the state's current emissions sources to establish a baseline of current emissions. The bill also requires the state Department of Environmental Protection to develop a plan to reduce statewide emissions.
Link to text of the bill:
http://www.legis.state.pa.us/cfdocs/legis/PN/Public/btCheck.cfm?txtType=HTM&sessYr=2007&sessInd=0&billBody=S&billTyp=B&billNbr=266&pn=1554

Observer to the Regional Greenhouse Gas Initiative (RGGI)

Wisconsin

Wisconsin's Strategy for Reducing Global Warming: Governor's Task Force on Global Warming, Department of Natural Resources, Public Service Commission of Wisconsin, July 2008

The report recommends a return to 2005 GHG emissions levels no later than 2014, a 22% reduction from 2005 levels by 2022, and a 75% reduction from 2005 levels by 2050. It also recommends several overarching policies including Improved Data Collection and Ongoing GHG Reduction Strategy, Evaluation, Development and Oversight; a Comprehensive Initiative to Support Voluntary Long-Term Greenhouse Gas Emissions Reductions; substantial increases in funding for Research and Development; Utility-Related Policies, Including Residential and Commercial Emissions; Transportation; Industry; Agriculture/Forestry; and a Carbon Tax/Carbon Trade Program
Link: http://dnr.wi.gov/environmentprotect/gtfgw/documents/Final_Report.pdf

Wisconsin is one of the two Great Lakes States that has imposed mandatory GHG emission reporting requirements. Wisconsin Administrative Code Chapter NR438 requires facilities emitting more than 100,000 tons/year of carbon dioxide to report emissions to the Wisconsin Department of Natural Resources.
Link to the bill:
http://www.pewclimate.org/docUploads/WI%20nr438%20%28mandatory%20reporting%29.pdf

Canada

City of Toronto

Toronto completed its first combined greenhouse gas and air quality emissions inventory in 2007. The inventory contains information about energy consumed and pollutants emitted by City government operations and the broader community.

Toronto's reduction targets for greenhouse gas emissions, from the 1990 levels of approximately 22 million tons per year city-wide, are:

- 6 percent by 2012 (1,320,000 tons per year)
- 30 percent by 2020 (6,600,000 tons per year)
- 80 percent by 2050 (17,600,000 tons per year)

http://www.toronto.ca/environment/air.htm

Toronto's Climate Change, Clean Air and Sustainable Energy Action Plan, adopted in 2007, includes:

- a **Live Green Toronto program**: a five-year, $20-million dollar program launched in 2008 that promotes and supports actions by residents and community groups to reduce emissions, clean the air and protect the climate. Its website, www.livegreentoronto.ca, has access to rebates, resources, tools and information about programs and supports at the municipal, provincial and federal levels. The program includes grants to help neighborhood and community groups initiate projects such as tree planting, energy efficiency, renewable energy production, local food production, green roofs, and water conservation.

- a framework to renew Toronto's concrete high-rise residential buildings
- a pilot program for residential solar hot water heating
- a "one-window" source of information on federal, provincial, municipal, private sector and community programs related to energy and the environment
- a plan to promote local food production and increase community gardens
- community energy planning
- a plan to double Toronto's tree canopy
- the development of a strategy to adapt to climate change
- a plan to shift taxis and limousines to low emission or hybrid technology.

The plan calls for initial funding of $42 million for energy conservation measures, $20 million for renewable energy projects and $22 million for retrofitting City facilities.

Link: http://www.toronto.ca/changeisintheair/index.htm

Toronto Atmospheric Fund

As a non-profit municipal agency, the Toronto Atmospheric Fund provides grants and loans in support of Toronto-based initiatives that combat global climate change and improve air quality.

Link: Toronto Atmospheric Fund

REGIONAL CLIMATE POLICIES

Midwestern Greenhouse Gas Reduction Accord

The Midwestern Greenhouse Gas Reduction Accord is a commitment by six Midwestern states and one Canadian province to reduce GHG emissions through a regional cap-and-trade program and other complementary policy measures. The Accord was signed in November 2007 as a part of the Midwestern Governors Association's (MGA's) Energy Security and Climate Change Summit. Iowa, Illinois, Kansas, Michigan, Minnesota, Wisconsin, and the province of Manitoba are members and full signatories of the Accord. Indiana, Ohio, South Dakota, and the province of Ontario joined the agreement as observers to participate in the development of the cap-and-trade system. The Accord represents the third regional agreement among U.S. states to collectively reduce GHG emissions.

The Midwestern Greenhouse Gas Reduction Accord Advisory Group finalized a set of recommendations in June 2009, which the governors of the member states are in the process of reviewing. The Advisory Group recommended the following emission reduction targets for the Accord members: 20% below 2005 levels by

2020; 80% below 2005 levels by 2050. A link to the Advisory Group's recommendations can be found here: http://www.midwesternaccord.org/GHG%20Draft%20Advisory%20Group%20Recommendations.pdf

The Accord is part of the Midwestern states' broader energy initiative. Through the MGA, these states have also agreed to an Energy Security and Climate Stewardship Platform, which lays out regional goals and policy options toward energy efficiency, renewable electricity, bio-based products and transportation, and advanced coal and carbon capture and storage.
http://www.midwesternaccord.org/

ADDITIONAL RESOURCES

Zhenghong Tang et al. "Moving from agenda to action: evaluating local climate change action plans", *Journal of Environmental Planning and Management*; Vol. 53, No. 1, January 2010, 41–62.

Climate change is conventionally recognized as a large-scale issue resolved through regional or national policy initiatives. However, little research has been done to directly evaluate local climate change action plans. This study examines 40 recently adopted local climate change action plans in the US and analyses how well they recognize the concepts of climate change and prepare for climate change mitigation and adaptation. The results indicate that local climate change action plans have a high level of 'awareness', moderate 'analysis capabilities' for climate change, and relatively limited 'action approaches' for climate change mitigation. The study also identifies specific factors influencing the quality of these local jurisdictional plans. Finally, it provides policy recommendations to improve planning for climate change at the local level.

Matthews, Lisa. "Regional Cap-and-Trade Programs to Cut Global Warming Emissions", *Environmental Council of the States, March 2009.*

In the absence of federal action, Northeastern, Mid-Atlantic, Western, and Midwestern states have adopted cap-and-trade programs to reduce global warming pollution in their respective regions. This experience will prove critical to smooth implementation of a federal climate program. While the effects of greenhouse gas (GHG) emissions are global, the manner in which reductions can best be achieved and impacts best mitigated will vary by state and region due to differing demographics, politics, and economics. This paper provides an overview of the three existing multi-state cap-and-trade programs: the Regional Greenhouse Gas Initiative (RGGI), the Western Climate Initiative (WCI), and the Midwestern Greenhouse Gas Reduction Accord (Accord). Together, 23 states are members and full signatories of these GHG reduction accords, and another nine states have joined the agreements as observers.

Climate Change and Climate Change Adaptation Planning Related Tools

Part 1: Resources and Tools Highlighted in Module 3: Resources and Tools for Climate Change Adaptation Planning

General Resources

Carr, Sarah. *Tools for Predicting and Mitigating Coastal Hazard and Climate Change* I*mpacts*. Ecosystem Based Management Tools, 2010.

This resource outlines helpful tools for climate change. This resource was used to determine whether or not the tool inventory was on the right track, and to determine whether or not more tools and resources needed to be added.
Keywords: Climate impacts; EBM Tools

Ecosystem Based Management Tool Inventory. Ecosystem Based Management Tools. 2010

This tool inventory is a searchable database on the Ecosystem Based Management Tools website. It is searchable by many different categories, and the tool inventory categories for this project and module were modeled after these categories.
Keywords: EBM Tools; Tool inventory

Laurentian Great Lakes Basin Climate Change Adaptation, Needs Assessment Synthesis. 2011. (Mini-grant needs assessment).

This needs assessment synthesis, also completed by the mini-grant team, identifies climate change adaptation related needs in the Great Lakes Basin. Needs are broken up into the following categories: Infrastructure: ports and regional planning; Infrastructure: water; Ecosystem-based management; Coastal planning and management; Hazard resilience and disaster preparedness.
Keywords: Great Lakes; Needs assessment

MRAG Americas. Feb 2009. Trends in Resource Management and Needs and Issues: a Literature Review. Report submitted to the NOAA Coastal Services Center: Charleston, SC.
<http://www.csc.noaa.gov/needsassesments/Coastal_Literature_Review.pdf>.

This needs assessment identified and discussed coastal management needs and issues. Conservation, habitat, and planning were some of the major issues identified that coastal managers must grapple with. The report indicated that coastal managers needed data that better fit their needs, and that the data needs to

be easily accessible, complete, and up-to-date. The report also suggested that coastal managers needed access to resources that will help them understand data, and communicate the data, and that the type of information that is most needed is information on human interactions with natural systems.
Keywords: Needs assessment; Resource management

MRAG Americas. April 2009. A Systematic Review of the Needs and Issues of the U.S. Coastal Resource Management Community: A Qualitative Meta-Analysis. Report submitted to the NOAA Coastal Services Center: Charleston, SC. <http://www.csc.noaa.gov/needsassesments/Coastal_Meta_Analysis.pdf>.

This needs assessment identified several needs among coastal management professionals, and was written for the NOAA Coastal Services Center. First, habitat issues and land planning issues came up as being very important. Also, there was a huge need for more decision support tools and more coordination and collaboration.
Keywords: Needs assessment; Coastal resources; Management

NOAA Coastal Services Center 2008. Summary Report for the Coastal Ecosystem-Based Management Course Needs Assessment.NOAA/CSC/RPT 08-01. Charleston, SC: NOAA Coastal Services Center. <http://www.csc.noaa.gov/needsassesments/(Economica%20Based%20Management)%20CSC%20EBM%20Training%20Needs%20Assessment_final.pdf>.

This report outlines the process that was used to help the NOAA Coastal Service Center develop an Ecosystem Based Management (EBM) training course for coastal managers. An on-line survey was conducted to get an idea of how much coastal managers knew about EBM practices and applications, which was used to guide the structure and content of the EBM training course.
Keywords: Needs assessment; EBM tools; Coastal management

NOAA Office of Ocean and Coastal Resource Management. "Adapting to Climate Change: A Planning Guide for State Coastal Managers."Web. 28 Dec. 2010. http://coastalmanagement.noaa.gov/climate/adaptation.html

The purpose of the document is to assist coastal managers and state level officials create adaptation plans to reduce the impacts of climate change. The document guides managers through the planning process.
Keywords: Planning; Coastal management

"Planning for Climate Change in the Great Lakes." Survey. NOAA, Sea Grant, Old Woman Creek. July 2010. (Cities Initiative Survey, Needs Assessment)

The categories from the needs assessment team survey for the Cities

Initiative 2010 meeting were used to help shape tool categories in this module. Results were taken into consideration, although given the small sample size, no large changes were made on module plans based solely on survey results.
Keywords: Survey; Needs assessment

Safford, T. Thompson, J., and P. Scholz. 2005. Storm Surge Tools and Information: A User Needs Assessment. NOAA Coastal Services Center. Charleston, SC.<http://www.csc.noaa.gov/needsassesments/(Storm%20Surge)%20finalstormsurgereport.pdf>.

The purpose of this needs assessment was to identify the current applications of storm surge models and related tools and resources, so that NOAA could improve their current storm surge resources. Needs identified in this report include: forecasting for storm surge needs to be improved to allow for 48-hours of prior notice; more education, outreach, and coordination was needed from NOAA; storm surge data needs to be updated to reflect changes in shoreline infrastructure and habitat.
Keywords: Needs assessment; Storm surge

Trumpickas, J., B. J. Shuter, and C. K. Minns. 2009. Forecasting impacts of climate change on Great Lakes surface water temperatures. Journal of Great Lakes Research 35:454-463.

This study utilizes remotely sensed data in order to build a model that explores patterns of lake level change associated with climate change in the Great Lakes. Lake levels and temperatures are modeled in order to predict future temperatures and levels in the Great Lakes.
Keywords: Remote sensing; Great lakes; Lake temperature; Lake level change

Case Studies

"Advancing Restoration in the Great Lakes Region." NOAA Digital Coast. Web 21 Dec. 2010.
<http://www.csc.noaa.gov/digitalcoast/action/advancerestoration.htm>.

This case study was displayed on the NOAA Coastal Services Center Digital Coast website. The material discussed how Habitat Priority Planner was used in habitat restoration projects in a section of the Buffalo River watershed in New York State and a section of the St. Joseph River watershed in Indiana. The software was used to identify areas that were suitable for conversion to wetlands and greenspace in the urban Buffalo River watershed environment, and to identify

areas that were suitable for conversion to wetlands in the agricultural St. Joseph River watershed.
Keywords: Habitat restoration; Watershed planning

The Conservation Fund. "Saginaw Bay Greenways Collaborative, Michigan." 2005. Print.

The Saginaw Bay Greenways Collaborative case study demonstrates how a collaborative group comprised of nonprofit organizations, local state and federal agencies as well as citizens worked to develop green infrastructure in Saginaw Bay, Michigan.
Keywords: GIS; Green infrastructure

"Building Coast-Smart Communities: A Role Play Exercise." Maryland Department of Natural Resources, Consensus Building Institute, MIT-USGS, 2009. Web. 15 Nov. 2010. <http://maryland.coastsmart.org/>.

This case study is available on the Building Coast Smart Communities website. The website describes how various community members from Maryland, from local business owners to state represntatives, attened a summit in order to participate in a climate impacts role play, where attendants were assigned characters in an advisory board and debated climate change issues from various viewpoints.
Keywords: Coastal management; Policy

*Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in the Waters of Duck Creek in Mendenhall Valley, Alaska.*Environmental Protection Agency, 2000. Web. 23 Dec. 2010.
<http://www.epa.gov/owow/tmdl/examples/pathogens/ak_duckcreek.pdf>.

In this case study, the Environmental Protection Agency used BASINS 4.0 to perform an analysis of fecal coliform bacteria in the Duck Creek watershed, located near Juneau, Alaska. This watershed has a very high level of fecal coliforms and other pollutants. The BASINS 4.0 SWMM model was used to establish a total maximum daily load for the watershed, and to make other recommendations for the management of the watershed.
Keywords: BASINS 4.0; Alaska; Water management

Community Outreach Tools

"Building Coast-Smart Communities: A Role Play Exercise." Maryland Department of Natural Resources, Consensus Building Institute, MIT-USGS, 2009. Web. 15 Nov. 2010. <http://maryland.coastsmart.org/>.

This tool is a half-day role-play exercise that encouraged participants to discuss climate change adaptation options and the challenges associated with climate change. It is targeted towards policy and Maryland in particular, but can be adapted for other areas. Materials can be downloaded for free from the above listed website.
Keywords: Role-play; Climate change discussion; Maryland; Policy

"Environmental Planning for Small Communities (TRILOGY)." Environmental Protection Agency, 1998. Web. 15 Nov. 2010. <http://www.purdue.edu/envirosoft/trilogy.html>.

This tool is intended to assist small to medium sized communities in the range of environmental issues they may face. Major components include: Environmental laws and regulations; Self-assessment; Planning and comparative risk analysis; Financial tools and financial self-analysis; Case studies; Contact and information directory.
Keywords: Small communities; Policy and planning

"Green Communities." Environmental Protection Agency. Web. 17 Nov. 2010. <http://www.epa.gov/greenkit/index.htm>.

This tool helps guide communities in creating a planning framework to help reduce environmental impacts. There are 5-steps in the process: 1. Community Assessment; 2. Trend Analysis; 3. Vision Statement; 4. Sustainable Action Plans; 5. Implementation. The website offers background information on the processes, displays case studies, and offers advice on how to get started.
Keywords: Planning and policy; Green infrastructure

Education, Training, and Support Tools

"Climate Adaptation Knowledge Exchange (CAKE)" Island Press; EcoAdapt. Web. 17 Nov. 2010. <http://www.cakex.org/about>.

This website lists climate change related tools and updates its site when new tools become available. Other information is available such as case studies, a virtual library, and a directory related to climate change information and adaptation efforts.
Keywords: Tool acquisition; Case studies

"Climate Change in the Great Lakes Region." Wisconsin Sea Grant. Web. 8 March 2011. <http://seagrant.wisc.edu/climatechange>.

This website provides information and resources on the Climate Change in the Great Lakes Region: Starting a Public Discussion seminars that were held between March September 2007. Available on the website is an 80-page summary report and DVD of the seminar that goes over the seminar topics: What

is known about climate change in the Great Lakes, What is predicted to occur with climate change, and measures that can be taken to adapt to climate change impacts. Users can also view PDF summaries, powerpoints, and videos of each individual seminar by clicking on “The Seminars” tab in the table of contents.
Keywords: Developing an adaptation plan; Background information

"Coastal Inundation Toolkit." NOAA Coastal Services Center Digital Coast. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/inundation/>.

This website offers various resources that assist in dealing with coastal inundation events. These situations occur when water covers land that is normally dry. There are six different categories users can choose from: “Understand (background information on the topic); Identify (discover potential impacts in your community); Maps (use maps to visualize the process); Assess (configure your community’s risk and vulnerabilities); Communicate (learn how to communicate what you have uncovered to your community); Discover (examine case studies on how communities are dealing with this issue).”
Keywords: Coastal inundation: Background information

"Coastal Services Center Training.” NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/training/>.

This website offers a number of online modules and lists of available in-person workshops. Workshops include a number of GeoSpatial Technology Courses and Coastal Management Training courses. Several online courses are also available: 1. Public Trust Doctrine On-Line Course; 2. Survival Skills for Coastal Resource Managers On-line Course; 3. Web Content Design and Evaluation On-line Course. Online Building Process Skills Courses include: 1. Negotiating for Coastal Resources; 2. Project Design and Evaluation; 3. Public Issues and Conflict Management; 4. Planning for Meaningful Evaluation. There is an additional online course called Conducting Needs Assessments
Keywords: Training; Workshops; Coastal management

"Ecosystem Based Management (EBM) Tools." Web. 15 Nov. 2010. <http://www.ebmtools.org/about_ebm_tools.html>.

This website offers a wide variety of tools and toolkits. Users can search the database for a tool that fits specific requirements. Tool ccategories include: Decision Support Tools; Modeling and Analysis Tools; Data Collection, Processing; Management Tools; Stakeholder Engagement and Outreach Tools; Conceptual Modeling Tools; Visualization Tools; Project Management Tools; Monitoring and Assessment Tools. This website also offers a wide range of training opportunities.
Keywords: Ecosystems; Tool acquisition

"Great Lakes Weather and Climate."Satellite Observations in Science Education. Web. 15 Nov. 2010. <http://www.ssec.wisc.edu/sose/glwx_activity.html>.

This website displays remote sensing images in order to explain Great Lakes weather and climate patterns. Module 'A' examines the reasons behind weather and climate patterns of the Great Lakes. Module 'B' examines patterns associated with spring and autumn while Module 'C' examines patterns associated with summer and winter.

Keywords: Remote sensing; Education; Modules

"Ohio Sea Grant Webinars." Ohio Sea Grant; Ohio State University. Web. 17 Nov. 2010. <http://www.ohioseagrant.osu.edu/>.

Ohio Sea Grant and Ohio State University offer educational webinars about once a month that cover climate change related topics in the Great Lakes Area. These modules can help participants learn more about how climate change may impact the Great Lakes area with respect to special topics or in more of a broad scope.

Keywords: Education; Great lakes

"Planning for Climate Change Workshop." National Estuarine Research Reserve Training System. Web. 17 Nov. 2010. <http://www.nerrs.noaa.gov/Training.aspx>.

The National Estuarine Research Reserve Training System will offer a Coastal Training Program specially made for Great Lakes coastal decision makers. The training will provide decision makers with the skills to plan for climate change issues in their communities. Information in the training will be customized for the Great Lakes region. Training will be available at a number of different locations, and will be coordinated through Old Woman Creek Reserve in Ohio. Training will be available in the spring of 2011.

Keywords: Coastal management; Education

Data Websites

"Coastal Change Analysis Program Regional Land Cover." NOAA Digital Coastal Services Center. Web 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/data/ccapregional/>.

This tool offers land cover land use data sets for coastal areas that can be downloaded for free. The Coastal Change Analysis Program updates data layers every five years, helping to monitor changes in coastal habitats. Remotely sensed

data is used to make the layers, with multiple dates so that users can see changes over time. Data is available for download and is in a raster format.
Keywords: Land use; Landcover; Remote sensing

"Coastal County Snapshots." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/snapshots/>.

Coastal County Snapshots is an interactive web-based tool that allows users to access information related to floodplains and flood zones in their area. Once the tool is launched, users click on a state within the United States, and then click on their county, if available (data is not available for every U.S. county). Then, users have access to county demographics within the floodplain, including population, infrastructure, and environment.
Keywords: Flood hazard; Country-specific data

“Great Lakes Information Network (GLIN) Maps and GIS.” Great Lakes Information Network. Web. 17 Nov. 2010. <http://www.gis.glin.net/>.

This GLIN webpage offers users a number of different GIS data layers specific to the Great Lakes region. The data is downloadable in a shapefile format, and can be found by searching by topic, organization, geography, or upload date. Topics include: Biota; Boundaries/Political; Climatology/meterology/atmosphere; Elevation; Environment; Geoscientific Information; Health; Imagery/basemaps/earth_cover; Inland Waters/Hydrography; Society; Structures/Facilities; and Transportation.
Keywords: ArcGIS; Shapefiles

"Historical Maps and Charts." NOAA Office of Coast Survey. Web. 15 Nov. 2010. <http://www.nauticalcharts.noaa.gov/csdl/ctp/abstract.htm>.

Users can access this free map and chart collection, which contains thousands of maps and charts from 18th century to modern day. Featured maps include nautical charts, hydrographic surveys, topographic surveys, etc.
Keywords: Mapping; Historical data

"MyEnvironment." Environmental Protection Agency. Web. 17 Nov. 2010. <http://epa.gov/myenvironment/>.

Users can enter in their zip code and receive health, air, ozone and other information specific to counties. They also have access to features like hazardous waste facilities mapping or cancer risks pie charts associated with their geographical location.
Keywords: Health; Hazards

“New York Ocean and Great Lakes Atlas.” State of New York. Web. 8 March 2011. <http://nyoglatlas.org/index.cfm?&userSkin=4>.

This link leads users to the New York Ocean and Great Lakes Atlas: Data Viewer, where users can view various data layers on New York and the Great Lakes in the area. Layer boundaries include, but are not limited to: administrative, New York State boundaries, watersheds, populations, estuaries, sewage treatment plants, and historic sites. This site is free to use and is meant to be accessed by the general public but would also be useful for government organizations, public companies, or universities.
Keywords: Data viewer; Coastal management; Atlas

"NOAA Digital Coast." NOAA Digital Coast. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/>.

The NOAA Digital Coast Website offers information on data, tools and training available to assist communities with coastal management issues. Users can search under various headings to see if new tools and updates are available. Stories are shared from around the United States, showing how the data and tools have been used successfully to manage the coasts. The website offers all types of resources that are related to coastal management, not necessarily all climate change related.
Keywords: Tool acquisition; Coastal managment

"NOS Data Explorer."NOAA National Ocean Service. Web. 17 Nov. 2010. <http://nosdataexplorer.noaa.gov/nosdataexplorer/>.

This tool is a collection of spatial information related to coastal areas and oceans, including "bathymetry, coastal maps, environmental sensitivity index maps, aerial photographs, etc." Users can download data from the site and utilize their interactive mapping tools.
Keywords: Coastal data; Database

"Ohio Coastal Atlas." Ohio Department of Natural Resources. Web 8 March. 2011. <http://www.ohiodnr.com/AtlasGIS/tabid/19562/Default.aspx>.

The Ohio Coastal Atlas is a collection of resources and maps on Lake Erie and its watershed. Resources include: a digital, interactive coastal atlas; maps; GIS data; and contacts. Users can also examine a wind turbine placement viewer, a ports and harbors map, a watersheds map, and coastal erosion areas.
Keywords: Data; Ohio; Lake Erie

"Wisconsin Coastal Atlas." Wisconsin Sea Grant. Web. 8 March 2011. <http://wiscoastatlas.net>.

This atlas provides access to maps, and other related data on Wisconsin and the Great Lakes. There are links that direct users to mapping sites like the Wisconsin County and Municipal Web Mapping Site, and maps like the Coastal

Heritage Tourism Map. There are also links to spatial data layers and websites, and spatial decision tools.
Keywords: Wisconsin; Maps; Data

Analysis Tools and Systems

\"BASINS (Better Assessment Science Integrating point and Non-point Sources) 4.0 Climate Assessment Tool (CAT)." EPA Global Change Research Program; EPA Office of Water, 2007. Web. 15 Nov. 2010. <http://water.epa.gov/scitech/datait/models/basins/index.cfm>.

BASINS allows users to explore possible effects of climate change on watersheds and water quality. This tool combines national watershed data, GIS, modeling tools, and assessment tools into an open-source GIS system. BASINS can be utilized for a number of different purposes and can be used by local, state, and regional organizations.
Keywords: Water quality; Watersheds; Modeling

“CITYgreen.” American Forests. Web. 17 Nov. 2010. <http://www.americanforests.org/productsandpubs/citygreen/>.

CITYgreen analyzes ecological and economic benefits of tree canopy and other green space. Stormwater runoff, air pollution removal, carbon storage and sequestration and, landcover breakdown are all analyzed by the software. Communities can use the alternate scenario modeling feature for decision-making and planning purposes.
Keywords: Green infrastructure; Planning and policy

"FEMA HAZUS." FEMA. Web. 15 Nov. 2010. <http://www.fema.gov/plan/prevent/hazus/index.shtm>.

FEMA offers free HAZUS software to federal, state, and local governments to assist in risk assessment and planning for mitigation efforts. FEMA HAZUS is meant to help prevent losses associated with disasters such as earthquakes, hurricanes, and flooding.
Keywords: Hazard assessment; Vulnerability assessment; Flood hazard; Disaster management; ArcGIS

"Habitat Priority Planner." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/hpp/>.

Habitat Priority Planner is a software tool that helps users make decisions related to “habitat conservation, restoration, and land use planning.” Users can examine various hypothetical situations and have access to data, including maps and reports that allow communities to make informed decisions and to more

efficiently communicate possibilities.
Keywords: Environmental analysis; Ecosystem restoration; Land use planning; Stakeholder engagement; Conservation

"Impervious Surface Analysis Tool." NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/isat/>.

This tool allows users to examine the percent of impervious surfaces in various areas, which can then be used to analyze possible water quality impacts of different management methods. This tool is meant to be an extension of ArcGIS and therefore requires that the tool be used in conjunction with ArcGIS software.
Keywords: Impervious surfaces; Water quality; ArcGIS

"i-Tree v3.0." United States Forest Service; Davey; Arbor Day Foundation; Society of Municipal Arborists; International Society of Arboriculture; Casey Trees Washington D.C.. Web. 17 Nov. 2010. <http://www.itreetools.org/index.php>.

I-Tree is a free software based tool that helps users quantify the benefits of trees and forests in their communities. The tool is applicable at multiple scales, ranging from a single tree to an individual forest to an entire state. Results generated from this tool can be used to help shape forest and tree management plans, involve and engage different stakeholders, among other applications. The i-tree v3.0 suite contains 5 parts: i-Tree Eco, i-Tree Species, i-Tree Streets, i-Tree Storm, i-Tree Vue.
Keywords: Urban forests; Forest management

"NatureServe Vista." NatureServe. Web. 17 Nov. 2010. <http://www.natureserve.org/prodServices/vista/overview.jsp>.

NatureServe Vista is an analysis system that can help decision makes and planners make land use and planning decisions while keeping a conservation framework in mind. The software can be assist users with carrying out conservation assessments and planning projects, to help planners incorporate conservation principles in land use planning, and evaluate current and potential land use strategies. NatureServe works to incorporate a number of different, important components including "science, expert opinion, community values, and GIS." The site offers a number of support avenues for users, from user forums to sample datasets to online technical support.
Keywords: Conservation; ArcGIS

"Nonpoint-Source Pollution and Erosion Comparison Tool." NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/nspect/>.

N-SPECT is a tool that can be used to determine what effects land use changes, especially development, may have on hydrologic systems. It can also be

used to examine effects on hydrologic systems from climate change. While N-SPECT can be used for various sized watersheds, it was created to mostly to examine medium and large sized watershed, but can apply to any.
Keywords: Pollution; Watershed management

"Roadmap for Adapting to Coastal Risk." NOAA Coastal Services Center Digital Coast. Web. 21 Dec. 2010. <http://www.csc.noaa.gov/digitalcoast/training/coastalrisk.html>.

This resource is a 3-hour, on-line risk assessment workshop. The workshop is offered through the NOAA Coastal Services Center Digital Coast, and helps participants assess current risk and future risk in their community. This workshop requires that participants have access to a phone and the Internet.
Keywords: Coastal ecosystems; Restoration

Other Informational Websites

"Lake Superior Duluth Streams.org." NOAA; Natural Resources Research Institute; Sea Grant Minnesota; United States Environmental Protection Agency; Minnesota Department of natural Resources; City of Duluth; Minnesota Pollution Control Agency. Web. 17 Nov. 2010. <http://www.lakesuperiorstreams.org/>.

This website offers information about streams, hydrology, and water management to interested parties in Minnesota and Wisconsin. Users can find information on hydrology, including stormwater and best management practices. Most information, such as permitting requirements and data on rivers, is specific to Minnesota and Wisconsin only; however there is also valuable information for other Great Lakes residents on concepts such as inflow and infiltration, and some general management practices.
Keywords: Watershed management; Stormwater management; Minnesota; Wisconsin

"NatureServe" (Website). NatureServe. Web. 21 Dec. 2010. <http://www.natureserve.org/>.

The NatureServe website offers tools and data to assist users incorporate conservation into land use and natural resource planning. Users can browse current NatureServe projects, find local programs, find species and ecosystem related data, and learn about other NatureServe resources. Under the "Products & Services" heading, users can download other NatureServe tools and learn about other services NatureServe can provide.
Keywords: Conservation; Software; Landuse planning

"NOAA Coastal Climate Adaptation." NOAA Coastal Services Center. Web 17 Nov. 2010. <http://collaborate.csc.noaa.gov/climateadaptation/default.aspx>.

The NOAA Coastal Climate Adaptation website offers information and resources on climate change for coastal communities in the United States. Users can search the resources category of the website, which lists resources for adaptation and action plans, outreach materials, stakeholder engagement, etc. Another feature of the website, called "Getting Started" helps communities get started on climate change adaptation.
Keywords: Coastal management; NOAA; Adaptation; Climate change

"NOAA Climate Services Portal." NOAA Climate Services. Web 17 Nov. 2010. <http://www.climate.gov/#climateWatch>.

This website offers climate information ranging from data and services to educational materials and information. The website allows users to browse ClimateWatch articles, and offers information to educate users on climate principles. Data is available on past climatic conditions and predictions. Users can also learn how to best use climate data in their own projects.
Keywords: Climate education; Data

"NOAA State of the Coast." NOAA; United States Department of Commerce. Web 17 Nov. 2010. <http://stateofthecoast.noaa.gov/>.

This website offers information about the importance of healthy coasts, and emphasizes the interconnectedness between the economy, communities, climate, and ecosystems. Users can learn about the demographics of people living in coastal areas, details of coastal economies and ecosystems, and how climate can impact all three.
Keywords: Coastal climate; Coastal ecosystem

Visualization Tools

"CanVis." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/canvis/>.

This tool assists users in visualizing potential impacts of coastal development and climate change. Users can add pictures of buildings or structures to see what impacts these developments may have on a larger scale. Users can play with various scenarios, such as and increasing or decreasing sea levels, in order to visualize potential climate change impacts. CanVIS is not a modeling system, and therefore users may need to base simulations on data from other models and predictions. This tool does not require extensive computer familiarity and users can upload their own photos. Users can also find images from the following website:
http://www.csc.noaa.gov/digitalcoast/tools/canvis/download.html
Keywords: Coastal development; Impact visualization

"Climate Wizard."The Nature Conservancy, University of Washington, and University of Southern Mississippi. Web. 15 Nov. 2010. <www.climatewizard.org/index.html>.

This tool illustrates various IPCC climate change scenarios in the US. Users can view averages and changes in temperature and precipitation in the past 50 years and projections into the future. Resources are also available that illustrate case studies and documentation.

Keywords: Climate change impacts; IPCC Predictions

“Visualizing Coastal Erosion.” University of Wisconsin. Web. 17 Nov. 2010. <http://www.geography.wisc.edu/coastal/>.

Visualizing Coastal Erosion is an interactive website that allows users to see the effects of coastal erosion in Ozaukee County, Wisconsin. Users have access to interactive exhibits that illustrate how erosion happens and depicts the change in landscape over the last 40 years, among over features.

Keywords: Erosion; Coastal development

Climatology

American Association of State Climatologists. Web 21 Dec. 2010. <http://www.stateclimate.org>.

This website directs users to their state climatologist, and their regional climatologist. There are currently 47 state climatologists and 6 regional climatologists and climatology centers. This website also offers information on current news, and has a interactive map where users can click on their state to get more information.

Keywords: Climatology; State and regional climatologists

“Illinois State Climatologist Office.” Illinois State Water Survey; Institute of Natural Resource Sustainability; University of Illinois at Urbana-Champaign, 2009. Web 18 Nov. 2010. <http://www.isws.illinois.edu/atmos/statecli/index.htm>.

This website has more information on the Illinois State Climatology Office, and about the state climatologist, Jim Angel. The website offers more information on climate products and topics, and lists current publications. There is also an online library to search publications.

Keywords: Climatology; State climatologist

“Indiana State Climatology Office.” Purdue University. Web 18 Nov. 2010. <http://iclimate.org/>.

This website has information on the state climatology office and the state climatologist, Dr. DevNiyogi. The Indiana State Climatology website also offers information on the climate in Indiana and on current research. Users can also request climate data from the office.
Keywords: Climatology; State climatologist

"Michigan State Climatologist's Office." Michigan State University Department of Geology; Michigan Agricultural Experiment Station; Michigan State University Extension; Southeast Michigan Council of Governments, 2009. Web 18 Nov. 2010. <http://climate.geo.msu.edu/>.

The Michigan State Climatology Office website offers information on the state climatology office and the state climatologist, Jeffrey Andreson. The website also has information on the Michigan State Agricultural Weather Office, and on Michigan Climate Maps. You can also access SEMCOG precipitation data and examine historical data.
Keywords: Climatology; State climatologist

"Midwestern Regional Climate Center." NOAA; Illinois State University Urgana-Champaign; Illinois State Water Survey, 2000-2010. Web 18 Nov. 2010. <http://mrcc.isws.illinois.edu/>.

The Midwestern Regional Climate Center serves 9 Midwestern states, including Minnesota, Iowa, Missouri, Wisconsin, Illinois, Indiana, Kentucky, Ohio, and Michigan. The Midwestern Regional Climate Center climatologist is Steve Hilberg. This website offers information on Midwest climates, and climate resources for Midwestern states.
Keywords: Climatology; State climatologist

"New York State Climatology Office." Cornell University; NOAA. Web 18 Nov. 2010. <http://nysc.eas.cornell.edu/>

The New York State Climatology office provides climate related information about the state of New York, and the state climatologist is Mark Wysocki. Climate information is available for selected cities in New York, and weather radar is also accessible.
Keywords: Climatology; State climatologist

"Northeast Regional Climate Center." Cornell University Department of Earth and Atmospheric Sciences; NOAA, 2009. Web. 18 Nov. 2010. <http://www.nrcc.cornell.edu/>.

The Northeast Regional Climate Center serves the Northeast region of the United States, which includes: Connecticut, Delaware, Massachusetts, Maryland,

Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. The website offers information on climate data for those 12 states, and the Northeast Regional Climate Center climatologist is Arthur DeGaetano.
Keywords: Climatology; Regional climatologists

“Office of State Climatologist for Ohio.” Ohio State University Department of Geography; Ohio State University Atmospheric Sciences Program. Web 18 Nov. 2010. <http://www.geography.ohio-state.edu/faculty/rogers/statclim.html>.

This website offers information on climate and weather in Ohio and the state climatologist is Jeffery Rodgers. There is information on Ohio’s current and past climates. There are also links to many other weather and climate resources on the website.
Keywords: Climatology; Regional climatologists

“The Pennsylvania State Climatologist.” College of Earth and Mineral Sciences; Pennsylvania State University. Web. 18Nov. 2010. <http://climate.met.psu.edu/www_prod/>.

This website is for the Pennsylvania State Climatology office, where Paul Knight is the state climatologist. You can find information on climate data in Pennsylvania and also learn more about extreme events and precipitation in Pennsylvania.
Keywords: Climatology; State climatologist

“Wisconsin State Climatology Office.” University of Wisconsin-Madison Department of Atmospheric and Oceanic Sciences, 2010. Web. 18 Nov. 2010. < http://www.aos.wisc.edu/~sco/>.

This website is for the Wisconsin State Climatology Office, where John Young is the state climatologist. You can find information on past climates in Wisconsin, or find other climate related data. Also there is a section on climate education and climate news.
Keywords: Erosion; Coastal development

Part 2: Tools Not Highlighted in Module 3: Resources and Tools for Climate Change Adaptation Planning

"Adaptation Actions Database." UK Climate Impacts Programme (UKCIP). Web. 15 Nov. 2010. <http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=286&

Itemid=423>.

This database was created as a way to share climate change adaptation approaches from organizations in the UK. This website provides case studies and information about how organizations are adapting to climate change. Users can search by regions and sectors to find out how nearby groups are adapting to climate change and to see what kind of challenges they may face.
Keywords: United Kingdom; Adaptation planning

"Adaptation Policy Frameworks (APF) for Climate Change: Developing Strategies, Policies, and Measures." United Nations Development Programme, 2004. Web. 15 Nov. 2010. <http://www.undp.org/climatechange/adapt/apf.html>.

A PDF is available on this website that guides leaders through creating and implementing policies that will help communities adapt to climate change. There are 5 stages in this framework: 1. Scoping and Designing an Adaptation Project; 2. Assessing Current Vulnerability of Development Objectives to Climate; 3. Assessing Future Climate Change Risks to the Development Objective; 4. Formulating an Adaptation Strategy; 5.Continuing the Adaptation Process through Monitoring and Evaluation
Keywords: Adaptation planning; Vulnerability assessments

"Adaptation to Climate Change Toolkit: Coasts - Marine Turtle Habitats." World Wildlife Fund. Web. 18 Nov. 2010. <http://www.panda.org/what_we_do/endangered_species/marine_turtles/lac_marine_turtle_programme/projects/climate_turtles/act_toolkit/>.

This tool is aimed at professionals who work with marine turtles. Climate change is expected to change habitats, and climate change may have a negative impact on sea turtle habitat. There are four main sections in this toolkit: 1. The Toolkit in brief. 2. The problem: impacts and vulnerability. 3. The solutions: adaptation measures and manuals. 4. Additional resources.
Keywords: Marine habitats; Turtles

"Adaptation Wizard." UK Climate Impacts Programme (UKCIP). Web. 15 Nov. 2010. <http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=147&Itemid=273>.

This tool is a step-by-step guide that assists users in determining the effect climate change may have on their area and how to adapt to those changes. There are 5-steps in this process: 1. Getting Started. 2. Am I vulnerable to the current climate? 3. How will I be affected by climate change? 4. What should I do? Do I know enough to act? 5. Keep it relevant. This tool helps users assess

vulnerabilities, determine what options are available to help with prominent risks, and then to finally develop a community specific adaptation plan.
Keywords: Developing an adaptation plan; Local effects of climate change

"Adapting to Climate Change: A Checklist for Development." London Climate Change Partnership, South East Climate Change Partnership, East of England Sustainable Development Round Table, Nov. 2005. Web. 18 Nov. 2010. <http://www.london.gov.uk/lccp/publications/development.jsp>.

This tool is a guide to help developers create projects that are sustainable and compatible with variations in climate anticipated from climate change. A major theme of the tool is that new developments should be made to ensure that it will be sustainable throughout major changes in the climate. It is available in PDF format
Keywords: Sustainable development; PDF

"ASA (Applied Science Associates) Inundation Toolbox." Applied Science Associates.Web. 18 Nov. 2010 <www.asascience.com/software/housetools/inundation-toolbox.shtml>.

This website provides users access to information about the Applied Science Associate's Inundation Toolbox. This toolbox combines storm surge data with the capabilities of GIS to map possible effects of anticipated storm surges. Users must work with ASA staff, who operate the model for them and provide mapping and other expertise.
Keywords: Modeling; GIS

"Base for Research, Adaptation, Impacts and News (the BRAIN)." UK Climate Impacts Programme (UKCIP). Web. 15 Nov. 2010. <http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=226&Itemid=324>.

This is a database that provides all types of information about climate change. Searchable categories include: Adaptation actions; Impacts of climate change/weather-related events; Research activities; Climate Digest. The database is searchable by keyword, and results are grouped by the above categories.
Keywords: Database, United Kingdom

"Beach Public Access." Oregon Coastal Atlas Inventory. Web. 15 Nov. 2010. <http://www.coastalatlas.net/index.php?option=com_content&task=view&id=20&Itemid=4>.

This tool keeps a detailed record of all public beach access points on the coastal areas of the State of Oregon. The main purpose to this tool is to provide

important beach access and other information to responsible parties so that they can keep track of public access points and avoid development in these places.
Keywords: Beach access; Coastal management

"Beach Water Quality." Oregon Beach Monitoring Program. Web. 15 Nov.2010. <http://www.coastalatlas.net/index.php?Itemid=40&option=com_custompages>.

This tool is targeted towards the public and is a method for residents to track the latest water quality at local beaches. The Oregon Beach Monitoring Program provides current information on water quality and also information and alerts on fecal bacteria in the water.

Keywords: Water quality; Community outreach

"Benthic Terrain Modeler." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/btm/index.html>.

This tool is a way for users to map deep-water environments. It is made up of ArcGIS-based tools and is intended for use by coastal and marine resource managers. This tool requires both ArcGIS 8.x or 9.0 with Service Pack 2 and the Spatial Analyst extension.
Keywords: GIS; Deepwater environment; Bathymetry; Data manipulation

"Business Assessment Tool." UK Climate Impacts Programme (UKCIP). Web. 15 Nov. 2010.
<http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=283&Itemid=382>.

This tool helps users understand the potential impacts of climate change in the business sector. A PDF is available called "A changing climate for business" which business owners can utilize in planning for the impacts of climate change on their business.
Keywords: Business sector; PDF

"The Clean Marina Classroom." Michigan Sea Grant. Web. 15 Nov. 2010. <http://www.miseagrant.umich.edu/cmp/workshop.html>.

This website offers information on an in-person course that teaches users how to effectively manage marinas. Topics covered in the workshop include: controlling pollutants in marinas, marina management, and environmental stewardship.
Keywords: Marina management; Education; Modules; Shoreline infrastructure

"Climate Change Community Toolbox." South Florida Regional Planning Council. Web. 15 Nov. 2010. <http://www.sfrpc.com/climatechange.htm>.

This website assists decision makers in adapting to climate change impacts. This tool is focused on South Florida, and has three main components: 1. Easy to comprehend “Climate Change Fact Sheets” that break down climate change impacts in one of the counties in Southern Florida. 2. A Sea level rise map atlas that maps different scenarios for sea level rise caused by climate change. 3. A collection of climate change resources, from both international and national sources.
Keywords: Adaptation planning; Florida; Atlantic/Gulf Coasts

"Climate Change Course." University of Wisconsin Madison. Web. 15 Nov. 2010. <http://cimss.ssec.wisc.edu/climatechange/>.

These modules are a means of explaining the results of the 2007 IPCC report on Climate Change and consists of 5 course units: Our Global Climate System; Observations of Climate Change; Global Climate Change; Climate Modeling; Regional Climate Change. Users need to register for the site so that they can take quizzes associated with each section.
Keywords: Education; IPCC report; Modules

"Climate Ready Estuaries Coastal Toolkit." Environmental Protection Agency. Web. 15 Nov. 2010. < http://www.epa.gov/CRE/index.html>.

This tool offers users a collection of information on climate change and coastal zones, including estuaries. Resources include: 1. Basic Information (background on climate change, potential impacts, and adaptation suggestions); 2. Where You Live (Information on National Estuary Program projects in your local area); 3. Explore Climate Ready Estuaries (examples of how the National Estuary Program is working with communities); 4. Coastal Toolkit (Information and tools that will help users begin adapting to climate change); News and events (current happenings in Climate Ready Estuaries program).
Keywords: Estuaries; Ecosystem Resiliency

“Climate Witness Community Toolkit.” World Wildlife Fund South Pacific Programme, April 2009. Web. 15 Nov. 2010. <http://www.panda.org/about_our_earth/all_publications/?162722/Climate-Witness-Community-Toolkit>

This PDF details a case study in Kabara, Fiji, where impacts of climate change are studied and an adaptation plan was devised to assist the community with climate change. This study stresses participation by local community members and developing strategies that are compatible with the local customs and culture.
Keywords: Community action; Developing an adaptation plan; Fijii

"Coastal Climate Adaptation." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://community.csc.noaa.gov/climateadaptation/index.php?option=com_docman&Itemid=32>

This website offers a list of tools for climate change adaptation. Under the resource tab, users can find information for Adaptation Guides, Plans and Examples; Tools for Adaptation; Impacts of Climate Change; Outreach and Education; Risk and Vulnerability Assessments; and Sea Level/Lake Change. *Keywords*: Vulnerability assessments; Shoreline infrastructure, Outreach; Education; Adaptation planning; Lake level change; Modules

"Coastal Ecosystem Restoration." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/coastal/>.

This systematic method is intended to assist users in breaking down coastal ecosystem conservation projects into manageable steps. Conservation projects are categorized into five components: Planning, Implementation, Performance Assessment, Adaptive Management, and Dissemination of Results. The website also offers background information on the importance of restoration and what kinds of challenges conservation projects may face.
Keywords: Ecosystem Resiliency; Conservation

"Coastal Glossary." International Coastal Atlas Network. Web. 15 Nov. 2010. <http://www.coastalatlas.net/index.php?option=com_glossary&Itemid=37>.

This tool is a glossary that defines coastal terms that may be unfamiliar, especially coastal management terms.
Keyword: Coastal terms; coastal management

"Coastal Inundation Visualization." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.coastalatlas.net/index.php?option=com_content&task=view&id=32&Itemid=4>.

Offers erosion, storm surge, and other information that can be used by those who plan for emergencies, community members, and those who work on local planning projects. *Note: Currently, this tool is not available due to upgrading and editing.
Keywords: Stormwater; Flood hazard; Emergency planning

"Coastal Resilience Mapping Tool." Coastal Resilience Long Island; The Nature Conservancy; NOAA; ASFM (Association of State Floodplain Managers); NASA

Goddard Institute for Space Studies; Pace Law School; University of Southern Mississippi; MSI (Marine Science Institute). Web. 15 Nov. 2010. <http://www.coastalresilience.org/>.

This website features information on flooding events and coastal issues that may occur with climate change in the Long Island, New York area. Users can examine the issue in depth, including what the risks are, and what mitigation and adaptation strategies are available. The Future Scenarios Map allows users to determine what the social, economic and ecological effects of flooding may be.
Keywords: Flood hazard; Adaptation planning; New York; Community outreach

Coller, Matthew, Peter Wheeler, Joshphar Kunapo, Jim Peterson, and Michael McMahon. "Lake Entrance Visualization Tool." Web. 15 Nov. 2010. <http://sahultime.monash.edu.au/LakesEntrance/>.

This tool allows users to visualize lake level change scenarios that are possible with climate change. Users can drag the lake level higher or lower and see what effect that will have on the city. This tool is specifically designed to model lake level changes in an Australian lake, but is also useful for visualizing lake level change in a general sense.
Keywords: Lake levels; Shoreline infrastructure; Australia; Flood hazard

“Community Risk Assessment Methodologies and Case Studies.” ProVention Consortium; The International Federation of Red Cross and Red Crescent Societies. Web. 15 Nov. 2010.
http://www.proventionconsortium.org/?pageid=43

Users can search through case studies and previously used methods on climate change adaptation. They can choose a geographical focus (including the United States, other countries, and a global focus) to find case studies specific to a particular area. Additionally, they can search by: Hazard risk type; Sector focus; Participatory tools; and more.
Keywords: Case studies; Adaptation planning

“Community VIZ.” Orton Family Foundation, 2010. Web. 15 Nov. 2010. <http://www.orton.org/tools/community_viz >.

This visualization tool is useful in community planning decisions. This GIS software is used for both communicating to the public and planning. It is made to be easy and convenient for users to operate.
Keywords: Visualization tool; Community outreach; Planning

“Community Vulnerability Assessment Tool (CVAT).” NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/rvat/>.

CVAT assists users in planning and conducting hazard assessments, which help them to identify potential hazards in their community. Communities can use CVAT to help them analyze potential economic, environmental, and societal impacts associated with hazards. A CD-ROM of CVAT can be ordered for free from the NOAA Coastal Services Center website.
Keywords: Hazard assessment; Hazards

"Compendium on Methods and Tools to Evaluate Impacts Of, and Vulnerability and Adaptation To, Climate Chnange." United Nations Framework Convention on Climate Change UNFCCC Secretariat, Feb. 2008. Web. 15 Nov. 2010. <http://unfccc.int/adaptation/nairobi_workprogramme/compendium_on_methods_tools/items/2674.php>.

A PDF report on the 2008 UNFCCC Compendium can be downloaded from this site. This report reviews available tools and methodologies in order to assist decision makers in developing strategies for climate change adaptation planning.
Keywords: Developing an adaptation plan; PDF

"Costing the Impacts of Climate Change." UK Climate Impacts Programme (UKCIP). Web. 15 Nov. 2010. <http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=69&Itemid=185>.

This tool allows users to determine costs associated with climate change and the costs associated with adaptation by performing their own cost benefit analysis. This tool includes information on how to identify costs, a spreadsheet for calculating costs, and case studies.
Keywords: Cost analysis; Adaptation

"CRiSTAL Community-Based Risk Screening - Adaptation and Livelihoods." International Institute for Sustainable Development (IISD); The World Conservation Union (IUCN); Stockholm Environment Institute (SEI-US); Intercooperation. Web. 15 Nov. 2010. < http://www.eldis.org/go/livelihoods/>.

This website offers information on how to develop policy and development plans that are based on "livelihood approaches," which are derived from a range of disciplines and focus on human centered approaches.
Keywords: Community outreach; Adaptation planning

"Electronic Navigational Chart Handler." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/enchandler/>.

This is a GIS-based tool allows users access to a database of navigational charts where they have access to over 150 potential data layers.

Keywords: Data; Navigational charts; GIS

"Great Lakes Fisheries Leadership Institute." NOAA; Sea Grant. Web. 15 Nov. 2010. <http://www.glerl.noaa.gov/seagrant/GLFLI/Notebook/Curriculum.html>.

This website offers a number of modules targeted towards stakeholders in the fishery industry. Categories of modules available include: 1. Aquatic Science; 2. Aquatic Nuisance Species Effects on Sustainability; 3. Fisheries Habitat; 4. Contaminant Issues Relevant to Great Lakes Fisheries; 5. Fisheries Management; 6. Institutional Arrangements for Great Lakes Fisheries Management; 7. Public Participation

Keywords: Fisheries; Modules; Education

"Green Communities." Environmental Protection Agency. Web. 17 Nov. 2010. <http://www.epa.gov/greenkit/index.htm>.

This tool helps guide communities create a planning framework to help reduce environmental impacts. There are 5-steps in the process: 1. Community Assessment; 2. Trend Analysis; 3. Vision Statement; 4. Sustainable Action Plans; 5. Implementation. The website offers background information on the processes, displays case studies, and offers advice on how to get started.

Keywords: Planning and policy; Green infrastructure

Hart, David, and Brea Lemke. "GIS Tools to Support Stormwater Management." Wisconsin Sea Grant; University of Wisconsin, 6 Mar. 2003. Web. 15 Nov. 2010. <http://coastal.lic.wisc.edu/stormwater/welcome.htm>.

Information from the "GIS Tools to Support Stormwater Management" workshop conducted by David Hart and Brea Lemke are available on this website. Users can access powerpoints and datasets from the workshop.

Keywords: GIS; Workshop; Stormwater

"Hazard Assessment Template." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/hat/>.

This is an internet-based tool that assists users in creating a website in order to map hazards that are associated with specified locations. In order to create your own website, you need a GIS experienced user and data that fits the following requirements: hazard zones, search layers like parcels, streets, villages; roads, boundaries, planning conservation or permitting zone data. This tool is typically utilized for permitting and planning purposes and also for hazard mitigation efforts.

Keywords: Coastal Services Center; Stormwater; Flood hazard; Shoreline Infrastructure; Conducting vulnerability assessments

"Historical Hurricane Tracks Tool." NOAA Coastal Services Center. Web. 15 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/hurricanes/>.

Users can examine historical paths of previous hurricanes by entering in information on their location (you can choose from: ZIP code, city, state, region, or latitude/longitude) or they can enter the name of a storm to track its path. This tool also includes data on coastal populations and users can use this tool to access storm reports. It is specific to the Atlantic coast and portions of the Pacific islands.
Keywords: Marine coast; Stormwater; Shoreline infrastructure; Flood hazard; Hurricanes

“How-to-Guides.” NOAA Coastal Service. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/howtoguides.html>.

This website offers links to websites and publications related to coastal management. There are resources for: Marine Boundaries, Social Sciences, Remote Sensing, Hazards, and Coastal Issues.
Keywords: Stormwater; Drought; Flood hazard; Ecosystem Resiliency; Shoreline infrastructure

"Inundation Mapping." NOAA National Weather Service. Web. 17 Nov. 2010. <http://water.weather.gov/ahps/inundation.php>.

This website allows users to access inundation maps from LiDAR data of various U.S. cities. Users can access flooding data from each area and view impacts from past flooding events.
Keywords: Inundation mapping; Stormwater; Flood hazard

“InVEST.” Nature Capital Project, 2006. Web. 17 Nov. 2010. <http://www.naturalcapitalproject.org/InVEST.html>.

This tool allows users to examine the costs and benefits associated with various land use and development scenarios. Users can choose between different outputs based on the complexity of data they need and how much data is available to input in the software. This software does require an ArcGIS capable user.
Keywords: GIS; Land use

"Land Use Portfolio Model." USGS (U.S. Geological Survey). Web. 17 Nov. 2010. <http://geography.wr.usgs.gov/science/lupm.html>.

This tool can assist leaders and communities in their efforts to map and understand risks from natural hazards.   It can also assist them in developing their own mitigation plans. This tool utilizes GIS, and incorporates economic factors into decision making and preparedness for disasters. The Land Use Portfolio

Model helps communities determine economical costs and benefits of decisions.
Keywords: Flood hazard; Risk; Emergency preparedness

"Legislative Access." NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/legatlas/>.

Users can click on an area on the map in order to determine which coastal and marine laws apply to the area. This tool also offers a database to search for marine and coastal laws, boundaries for particular laws and jurisdictions, and allows users to download legislative information. In order to use this software, ArcGIS is required.
Keywords: GIS; Ocean management

"Lidar Data Handler." NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/lidarhandler/>.

This is a GIS-based tool that allows users to manipulate LiDAR datasets. ArcGIS is required to operate the software.
Keywords: GIS; LiDAR

"LIDAR Data Retrieval Tool." NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://maps.csc.noaa.gov/TCM/>.

Customers can use this tool to access LIDAR data from the NOAA Coastal Services Center Archive. It is intended for the general public, coastal managers and other scientists. This tool offers an interactive format where customers can personalize their output.
Keywords: LiDAR; Data manipulation

"List of Reusable Content Objects (RCOs)." Satellite Observations in Science Education. Web. 17 Nov. 2010. <http://www.ssec.wisc.edu/sose/rco/>.

This webpage has a list of the RCOs available on the Satellite Observations in Science Education website. The categories for RCOs include: Satellite Imagery Display and Analysis, Data Plotting and Visualization, Organization and Display of Textual Information, Sequential Mixed-Content Display, User Input Validation
Keywords: Data; Remote sensing

"Local Climate Impacts Profile (LCIP)." UK Climate Impacts Programme (UKCIP). Web. 17 Nov. 2010. <http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=278&Itemid=377>.

This tool is intended to help local authorities determine what climate

change adaptations may be necessary in their area. Information is available on how to conduct an LCLIP (Local Climate Impacts Profile), next steps in the process, and case studies.
Keywords: Adaptation planning, United Kingdom

"Local Government Climate Change Adaptation Toolkit." ICLEI Local Governments for Sustainability, Cities for Climate Protection Australia Adaptation Initiative. Web. 17 Nov. 2010. <http://www.iclei.org/index.php?id=adaptation-toolkit>.

This toolkit is specifically designed for Australian local governments to set up their own adaptation strategies. The toolkit contains 14 tools that are designed to guide communities through each step of the process.
Keywords: Adaptation planing; Australia

"MAGICC/SCENGEN." US EPA (Environmental Protection Agency); UCAR (University Corporation for Atmospheric Research); NCAR (National Center for Atmospheric Research), 2007. Web. 4 May 2010. <http://www.cgd.ucar.edu/cas/wigley/magicc/index.html>.

MAGICC and SCENGEN are two tools that are used in conjunction with one another in order to predict the effects of climate change on specific regions and also the entire globe. MAGICC is first used to predict future emissions levels and the effects of predicted emissions on temperature and rise in sea level. SCENGEN links this information with geospatial data in order to map the outcome from the MAGICC modeling system.
Keywords: Modeling; Climate scenarios

"Marine Traffic." Department of Product and System Engineering, University of the Aegean. Web. 17 Nov. 2010. <http://www.marinetraffic.com/ais/addyourarea.aspx?level1=150>.

This tool gives up-to-date information on the positioning of ships. It can be set up so that the tool covers the area of a user's choosing. Information for this tool comes directly from the ships themselves, as they send information on their positions through the radio.
Keywords: Nautical information; shipping

"Multipurpose Marine Cadastre." NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/mmc/index.html>.

This tool helps users with development and planning in marine areas, especially projects that involve renewable energy. Users can access federal and state cadastral data and laws and restrictions associated with development in

certain areas.
Keywords: Shoreline infrastructure; Vulnerability assessments

"Nautical Chart Reprojector." NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/chartreprojector/>.

This tool helps users re-project raster NOAA nautical charts. The tool is stand-alone and does not require any other specialized software (i.e. GIS)
Keywords: Nautical charts; Data manipulation

"Nautical Chart Viewer." NOAA Coastal Services Center. Web 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/tools/chartviewer/>.

This tool helps users view nautical chart information in a BSB format in a GIS environment. This tool does require ArcGIS software.
Keywords: GIS; Nautical charts

“NOAA Coastal Climate Adaptation.” NOAA Coastal Services Center. Web 17 Nov. 2010. <http://collaborate.csc.noaa.gov/climateadaptation/default.aspx>.

The NOAA Coastal Climate Adaptation website offers information and resources on climate change for coastal communities in the United States. Users can search the resources category of the website, which lists resources for adaptation and action plans, outreach materials, stakeholder engagement, etc. Another feature of the website, called “Getting Started” helps communities get started on climate change adaptation.
Keywords: Coastal management

“NOAA Digital Coast.” NOAA Digital Coast. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/digitalcoast/>.

The NOAA Digital Coast Website offers information on data, tools and training available to assist communities with coastal management issues. Users can search under various headings to see if new tools and updates are available. Stories are shared from around the United States, showing how the data and tools have been used successfully to manage the coasts. The website offers all types of resources that are related to coastal management, not necessarily all climate change related.
Keywords: Tool acquisition; Coastal management

"NOAA Heat/Health Watch Warning System." NOAA; University of Miami, 2005. Web. 17 Nov. 2010. <http://www.noaanews.noaa.gov/stories2005/s2366.htm>.

This website provides a warning for excessive heat, which may become valuable for communities that are affected by extreme temperatures associated with climate change.

Keywords: Health; Urban heat islands

"Nottingham Declaration Action Pack." Web. 17 Nov. 2010. <http://www.energysavingtrust.org.uk/nottingham>.

This website will link users to the Nottingham Declaration on Climate Change page, where they can request a copy of the Nottingham Declaration, which is a declaration that British decision makers can sign vowing to tackle climate change issues in their councils.
Keywords: Adaptation planning, Community outreach

"OrCOOS Near-Real Time Data." Oregon Coastal Ocean Observing System. Web. 17 Nov. 2010. <http://agate.coas.oregonstate.edu/data_index.html>.

This website was created to establish a system that could monitor the use of Oregon's coastal areas and promote the sustainable and responsible utilization resources associated with coastal areas. Many of the features are almost real time, and you can find information on mooring, remote sensing, and other data.
Keywords: Coastal area monitoring; resource management

"Oregon Coastal Atlas." International Coastal Atlas Network. Web. 17 Nov. 2010.
<http://www.coastalatlas.net/index.php?option=com_frontpage&Itemid=1>.

This website offers users a range of resources related to coastal management and coastal issues. There is an internet map server that acts as a simple alternative to GIS. This Maps section offers users the option to personalize maps and utilize data from the Atlas archives. There is also information on tools related to coastal areas, and more information on coastal issues and topics.
Keywords: Oregon; Coastal atlas

"Oregon Explorer - Natural Resources Digital Library." Oregon State University. Web. 17 Nov. 2010. <http://oregonexplorer.info/>.

Oregon Explorer allows users to access free geospatial data. This data is intended for use by a wide variety of users, from researchers to business owners. Datasets were compiled in a partnership between Oregon State University and the Institute for Natural Resources. The data on the Oregon Explorer is intended for a wide range of audience members, from the public at large to researchers.
Keywords: Database; Geospatial data; Oregon

"Risk and Vulnerability Assessment Tool." NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.csc.noaa.gov/rvat/>.

This tool is indented to help users identify hazards and risks in their area. Includes four parts: Risk and Vulnerability Assessment (using the Community Vulnerability Assessment Tool (CVAT)); Interactive Mapping; Community Rating System; Storm Surge Visualization. Interactive mapping is specific to Brevard and Volusia Counties, Florida and shows vulnerable locations within this area. This tool also includes a step-by-step guide of risk and vulnerability assessments. A community rating system illustrates how to get community members involved in decisions related to floodplain management. Storm surge visualization is available for Brevard and Volusia Counties that illustrates various scenarios in 3D. (This feature requires Real Player or Windows Media Player)
Keywords: Florida; Marine Coast; Flood hazard: Shoreline infrastructure; Stormwater; Vulnerability assessments

"Risk Framework." UK Climate Impacts Programme (UKCIP). Web. 17 Nov. 2010.
<http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=62&Itemid=184>.

This tool is a step-by-step guide that helps users lay the foundation for a climate change adaptation plan. This guide mainly helps users determine climate change related risks in their communities so that they are able to determine which impacts they need to plan for. Through this tool, users can sign up for training (both online and in person) and can examine case studies.
Keywords: Adaptation planning; Risk assessment

"Socio-economic Scenarios." UK Climate Impacts Programme (UKCIP). Web. 17 Nov. 2010.
<http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=21&Itemid=196>.

This tool helps users determine potential socio-economic effects of climate change, and explains how changes in the socio-economic climate can alter responses to climate change. This tool is available in a PDF format.
Keywords: Economic impacts; Vulnerability assessments

"SimCLIM." CLIMsystems Ltd. Web. 17 Nov 2010.
<http://climsystems.com/simclim/>.

SimCLIM is a modeling system that can be utilized to display possible climate change impacts in a specific area. This tool can be used to determine possible climate change related risks and to determine how sensitive an area may be to climate change, among other applications.
Keywords: Vulnerability assessment; Modeling

"SLAMM: Sea Level Affecting Marshes." Warren Pinnacle Consulting, Inc. Environmental Modeling. Web. 17 Nov. 2010. <http://www.warrenpinnacle.com/prof/SLAMM/index.html>.

This tool helps to illustrate the anticipated effects of climate change and rising sea level on wetland ecosystems. Users can see maps of current wetland locations and also maps of projected changes in wetland distribution as sea level rises.

Keywords: Wetlands; Shoreline infrastructure; Vulnerability assessments; Flood hazard

"SLOSH (Sea, Lake, and Overland Surges from Hurricanes) Model." National Hurricane Service, NOAA, National Weather Service, FEMA. Web. 17 Nov. 2010. <http://www.nhc.noaa.gov/HAW2/english/surge/slosh.shtml>.

SLOSH is a widely used storm surge prediction model that is used to predict storm surge heights and wind intensity of hurricanes. It can be used to predict storm surges associated with immanent hurricanes, but can also be used to test hurricane scenarios and determine storm intensity of past hurricanes. This model takes various measurements associated with a hurricane (Pressure, Size, Forward speed, Track and Winds) and predicts storm surge intensity.

Keywords: Stormwater; Flood hazard; Disaster preparedness; Hurricanes

“Smart Growth Index.” US Environmental Protection Agency, 2002. Web 17 Nov. 2002. <http://www.epa.gov/dced/topics/sg_index.htm>.

This tool is a GIS based modeling tool that assists users to simulate various land use scenarios. It is fit to specific communities and allows users to determine the outcome and impacts of various land use scenarios, thus helping to determine which strategies are “smart growth” options for each community. *Note this tool does not yet appear to be widely available, and appears to still be in piloting stages.

Keywords: Visualization tool, Shoreline infrastructure, Ecosystem Resiliency

"Tools Portfolio." UK Climate Impacts Programme (UKCIP). Web. 17 Nov. 2010. <http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=406&Itemid=448>.

This tool offers users a flow chart that suggests ways in which the various tools on the UKCIP website can be used in conjunction with one another.

Keywords: Tool integration; Flow chart

"UK Climate Scenarios." UK Climate Impacts Programme (UKCIP) and Met Office Hadley Center. Web. 17 Nov. 2010. <http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=156&Itemid=288>.

This website offers a link that will introduce users to the basic ideas presented in the UK Climate Projections (UKCP09). The link provides access to data from the report as well as graphs and advice on how to utilize the findings of the study.

Keywords: UK; Climate tools; UKCP09

"Urban Heat Islands (or UHI)." Cooperative Institute for Meteorological Satellite Studies. Web. 17 Nov. 2010. <http://cimss.ssec.wisc.edu/climatechange/globalCC/lesson7/UHI2.html>.

This website provides an introduction to what urban heat islands are and has charts and diagrams that help to illustrate the topic.

Keywords: Visualization tools; Urban heat islands

"V-Datum Transformation Tool." NOAA Office of Coast Survey. Web. 17 Nov. 2010. <http://vdatum.noaa.gov/>

This tool can transform datasets from one vertical datum to another, which is crucial when you need to combine or compare datasets that have different datums.

Keywords: Data manipulation; Data transformation

"Washington State Coastal Atlas." Department of Ecology, University of Washington; Washington State Department of Natural Resources; NOAA Coastal Services Center. Web. 17 Nov. 2010. <http://www.ecy.wa.gov/programs/sea/sma/atlas_home.html>.

This coastal atlas allows users to learn about Washington's shoreline, by looking at land cover, habitat types, regulated features, physical features, regulated areas and more. Viewers can zoom in on the map, pan, and select areas, among other functions.

Keywords: Shoreline infrastructure; Vulnerability assessments

"Weather and Climate Activities to Explore the Atmosphere." University of Wisconsin Madison. Web. 17 Nov. 2010. < http://cimss.ssec.wisc.edu/wxfest/>

12 Applets that describe weather and climate concepts such as tornadoes, past climate, relative humidity, etc.

Keywords: Weather; Visualization tools

"West Coast Habitat Portal." Pacific Coast Ocean Observing System (PaCOOS). Web. 17 Nov. 2010. <http://nwioos.coas.oregonstate.edu/>.

The West Coast Habitat Portal is a data network that offers marine datasets from various providers like NOAA Fisheries Marine Fisheries Services, and Pacific States Marine Fisheries Commission. Users can access datasets on coastal habitats, tectonic activities in the area, various sediments, information on wildlife, and others.

Keywords: Marine datasets; Data manipulation

Laurentian Great Lakes Basin
Climate Change Adaptation

Needs Assessment Synthesis

June 2010

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Report prepared for National Oceanic and Atmospheric Administration
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
and Ohio State Nature Preserve (ODNR/Division of Wildlife)

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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.

Method

The methodology outlined in the NOAA Coastal Services Center needs assessment training module[7] 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 six through twelve).

Goals and Objectives

This 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.

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

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

- 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

Phase I: Research Planning

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 thirteen major urban areas in the Great Lakes basin.

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. 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[8]. 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[9].

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.”[10]

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[8] 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>

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

[10] “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.

Initial GLSLCI[11] Community Input: Audience and Issues

As a first step in the needs assessment process, the team gathered the perspectives of three Great Lakes & 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 Councilmembers
    - Township Trustees
    - Mayors
    - County Commissioners

[11] 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[12].

GLSLCI Meeting Attendee Input[13]:
Awareness, Adaptation Planning Status, Resource, Tool, & 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).

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

[13] 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).

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.

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. This data is 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[14].

"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."[15]

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

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[14] 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>

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

here, and should be referenced in its entirety[16], as well as the Climate-Related Needs Assessment Synthesis report in 2008 for the NOAA Coastal Services Center[17].

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)[18].

Please 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.

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[16] 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.

[17] 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/>

[18] 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.

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.

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 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.

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.

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 operations
  - Port 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

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
- 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

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-stimulis measures now being developed should address wastewater system needs in the Great Lakes basin" (IJC, 2009).

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.

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.

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.

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

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.

<u>Specific barriers to climate adaptation:</u>

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

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.

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.

<u>Adaptation Needs: Research, Planning, and Policy</u>

- 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)

<u>Adaptation Needs: Education and Training</u>

- 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

<u>Specific Issue Areas</u>

Watershed planning & 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.

<u>Relevant roles</u>

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

<u>Adaptation Needs: Research, Planning and Policy</u>

- *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.

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).

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.

<u>Relevant roles</u>

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

<u>Specific Adaptation Needs</u>

- 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.

Invasive Species

<u>Climate Impacts</u>

- 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 CO_2 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)

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

<u>Specific barriers to climate adaptation:</u>

- 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

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.

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.

<u>Adaptation Needs: Research, Planning, and Policy</u>

- 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

<u>Adaptation Needs: Education and Training</u>

- 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

Specific Issue Areas

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.

Relevant Roles

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.

Specific Adaptation Needs

- 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

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[19], 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.
- 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.

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[19] 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.

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.

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

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.

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)

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

<u>Adaptation Needs: Education and Training</u>

- 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

<u>Specific Issue Areas</u>

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

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

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

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 Rochester, NY; Ajax, Ontario; and Superior, WI [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?

Ajax, 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."

Rochester, NY:
- 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

Superior, WI:
- 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?

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

Rochester, NY:
• Budgets
• Energy
• Drinking water quality
• Drinking water infrastructure
• Stormwater infrastructure
• Wastewater infrastructure
• Shoreline infrastructure
• Wetlands
• Streams and rivers
• Beaches and coastal ecosystems
• Public health

Superior, WI:
• Ports
• Drinking water quality
• Drinking water infrastructure
• Stormwater infrastructure
• Wastewater infrastructure
• Shoreline infrastructure
• Beaches and coastal ecosystems

<u>Great Lakes Climate Adaptation Tool Handout</u>
<u>January 2011</u>

Introduction

This handout is a compilation of tools and resources that can provide assistance to Great Lakes coastal communities in their climate change adaptation efforts. Each resource or tool was selected based upon potential applicability to the Great Lakes region and usefulness in climate change adaptation. City planners and other similar professionals can use these tools and resources to facilitate action on numerous levels. A few applications for the tools include decision-making support, improving communication with the public, understanding risk and vulnerability to various climate change scenarios as well as predicting future scenarios for planning and goal implementation.

Tool complexity and application varies but all can be adjusted to fit Great Lakes communities. Some tools are computer software programs while others are methods, databases or web applications. The tools are broken down into six categories for easy reference: Community Outreach Tools; Education, Training, and Support Tools; Data Websites; Other Informational Websites; Analysis Tools and Systems; Visualization Tools. There is also supplementary contact information listed at the end of the handout with information on state and regional climatologists and climatology offices.

Community Outreach Tools

In general, community outreach tools help decision makers communicate with the public and interpret policy/decision making processes so that solutions are accessible to the public at large. The following Role playing tool facilitates climate change discussions among stakeholders to show the varying perspectives from many different sectors (business owners, environmental professionals, politicians, and others). Other tools in this section assist with various planning challenges. These tools are applicable throughout the climate change adaptation planning process, but should be used heavily at the beginning of the process to gain community support.

- **Building Coast-Smart Communities: A Role Play Exercise**
  http://maryland.coastsmart.org
  This tool is a half-day role-play exercise that encouraged participants to discuss climate change adaptation options and the challenges associated with climate change. It is targeted towards policy and Maryland in particular, but can be adapted for other areas. Materials can be downloaded for free from the above listed website.

Contact: For more information about the role-play exercise and the Coast-Smart Initiative, please send an email to info@coastsmart.org or call the Chesapeake & Coastal Program at the Maryland Department of Natural Resources at (410) 260-8743 or David Plumb at the Consensus Building Institute at (617) 844-1128
Keywords: Role-play; Climate change discussion; Maryland; Policy
Cost: None
Training/Time Requirements: ½ day course
Other Requirements/Notes: None

- **Environmental Planning for Small Communities (TRILOGY)**
  http://www.purdue.edu/envirosoft/trilogy.html
  This tool is intended to assist communities, from small to medium in size, with the range of environmental issues they may face. Major components include: Environmental laws and regulations; Self-assessment; Planning and comparative risk analysis; Financial tools and financial self-analysis; Case studies; Contact and information directory.
  Contact: Users can fill out a question form at:
  http://www.purdue.edu/envirosoft/comment.html
  Keywords: Small communities; Policy and planning
  Cost: Free
  Training/Time: Varies
  Other Requirements/Notes: It is necessary that users have a Windows 3.1 or Windows 95 or higher operating systems, and that they have at least 55 Mb free on their hard drive.

- **Green Communities**
  http://www.epa.gov/greenkit/index.htm
  This tool helps guide communities in creating a planning framework to help reduce environmental impacts. There are 5-steps in the process: 1. Community Assessment; 2. Trend Analysis; 3. Vision Statement; 4. Sustainable Action Plans; 5. Implementation. The website offers background information on the processes, displays case studies, and offers advice on how to get started.
  Contact: Francesca Di Cosmo, dicosmo.francesca@epa.gov
  Keywords: Planning and policy; Green infrastructure
  Cost: Free
  Training/Time: Varies
  Other Requirements/Notes: None

Education, Training, and Support Tools

This category links education, training, and support tools. Some tools offer information on climate change, which can be used as educational resources for decision makers or for outreach. Some tools offer training on many topics, including managing coastal areas and GeoSpatial technology. Finally, some tools are databases that can help users find additional tools for adaptation planning.

Education, training, and support tools should be utilized both early on and throughout in the adaptation planning process.

- **Climate Adaptation Knowledge Exchange (CAKE)**
  http://www.cakex.org/tools
  This website lists climate change related tools and updates its site when new tools become available. Other information is available such as case studies, a
  virtual library, and a directory related to climate change information and adaptation efforts.
  Contact: EcoAdapt (206-201-3834)
  Users can also contact the CAKE website with questions at:
  http://www.cakex.org/contact/information_request
  Keywords: Tool acquisition; Case studies
  Cost: None (time to search website)
  Training/Time Requirements: None (time to search website/learn about tools)
  Other Requirements/Notes: None

- **Climate Change in the Great Lakes Region**
  http://seagrant.wisc.edu/climatechange/
  This website provides information and resources on the Climate Change in the Great Lakes Region: Starting a Public Discussion seminars that were held between March September 2007. Available on the website is an 80-page summary report and DVD of the seminar that goes over the seminar topics: What is known about climate change in the Great Lakes, What is predicted to occur with climate change, and Measures that can be taken to adapt to climate change impacts. Users can also view PDF summaries, powerpoints, and videos of each individual seminar by clicking on "The Seminars" tab in the table of contents.
  Contacts: David Hart, dhart@aqua.wisc.edu
  Keywords: Developing an adaptation plan; Background information
  Cost: None for web-based PDF; $13.50 for a printed copy; $5 for a DVD copy of the seminar
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **Coastal Inundation Toolkit**
  http://www.csc.noaa.gov/digitalcoast/inundation
  This website offers various resources that assist in dealing with coastal inundation events that occur when water covers land that is normally dry. There are six different categories users can choose from: "Understand (background information on the topic); Identify (discover potential impacts in your community); Maps (use maps to visualize the process); Assess (configure your community's risk and vulnerabilities); Communicate (learn how to communicate what you have uncovered to

your community); Discover (examine case studies on how communities are dealing with this issue).”
Contact: Doug Marcy, Doug.Marcy@noaa.gov
Users can also submit questions at the following website:
http://www.csc.noaa.gov/digitalcoast/feedback.html
Keywords: Coastal inundation; Background information
Cost: None
Training/Time Requirements: None
Other Requirements/Notes: None

- **Coastal Services Center Training**
  http://www.csc.noaa.gov/training
  This website provides information on a number of online modules and in-person training courses. Training opportunities include GeoSpatial Technology Courses and Coastal Management Courses. Process Skills Courses are also available including: 1. Negotiating for Coastal Resources; 2. Project Design and Evaluation; 3. Public Issues and Conflict Management; 4. Planning for Meaningful Evaluation. Several online courses are also available: 1. Public Trust Doctrine; 2. Survival Skills for Coastal Resource Managers ; 3. Web Content Design and Evaluation; 4. Conducting Needs Assessments.
  Contact: Varies, depending on the course but can be accessed on the website.
  The main contact is Mary Culber, at Mary.Culber@noaa.gov
  To request in-person trainings, send an e-mail to csc.training.request@noaa.gov.
  Users can fill out a question form at:
  http://www.csc.noaa.gov/contact/contactForm.htm
  Keywords: Training; Workshops; Coastal management
  Cost: Varies
  Training/Time Requirements: Varies
  Other Requirements/Notes: None

- **Ecosystem Based Management (EBM) Tools**
  http://www.ebmtools.org/about_ebm_tools.html
  This website offers a wide variety of tools and toolkits. Users can search the database for a tool that fits specific requirements. Tool categories include: Decision Support Tools; Modeling and Analysis Tools; Data Collection, Processing; Management Tools; Stakeholder Engagement and Outreach Tools; Conceptual Modeling Tools; Visualization Tools; Project Management Tools; Monitoring and Assessment Tools. This website also offers a wide range of training opportunities.
  Contact: Sarah Carr, ebmtools@natureserve.org
  Keywords: Ecosystems; Tool acquisition
  Cost: No cost to search website

Training/Time Requirements: None (time to search website/learn about tools)
Other Requirements/Notes: None

- **Great Lakes Weather and Climate**
  http://www.ssec.wisc.edu/sose/glwx_activity.html
  This website displays remote sensing images in order to explain Great Lakes weather and climate patterns. Module 'A' examines the reasons behind weather and climate patterns of the Great Lakes. Module 'B' examines patterns associated with spring and autumn while Module 'C' examines patterns associated with summer and winter.
  Contact: Richard Wagenmaker Richerd.Wagenmaker@NOAA.gov
  Keywords: Remote sensing; Education; Modules
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **Ohio Sea Grant Webinars**
  http://www.ohioseagrant.osu.edu/
  Ohio Sea Grant and Ohio State University offer educational webinars about once a month that cover climate change related topics in the Great Lakes Area. These modules can help participants learn more about how climate change may impact the Great Lakes area with respect to special topics or in more of a broad scope.
  Contact: Jill Jentes-Banicki jents.1@osu.edu
  Please visit the Ohio Sea Grant contact webpage: http://www.ohioseagrant.osu.edu/contact/ to find a contact that fits your needs. Otherwise, you can choose to “leave a note” and the office will help answer your question or direct you to a particular person.
  Keywords: Education; Great Lakes
  Cost: Free for most
  Training/Time Requirements: The time it takes to attend the webinar
  Other Requirements/Notes: Most webinars are free, but pre-registration is required

- **Planning for Climate Change Workshop**
  http://www.nerrs.noaa.gov/Training.aspx
  The National Estuarine Research Reserve Training System will offer a Coastal Training Program specially made for Great Lakes coastal decision makers. The training will provide decision makers with the skills to plan for climate change issues in their communities. Information in the training will be customized for the Great Lakes region. Training will be available at a number of different locations, and will be coordinated through Old Woman Creek Reserve in Ohio.
  Contact: Heather Elmer Heather.Elmer@dnr.state.oh.us
  Keywords: Coastal management; Education

Cost: Varies depending on location
Training/Time Requirements: Not Yet Determined
Other Requirements/Notes: Training will be available spring 2011

Data Websites

The following resources are places that users can locate data to use in conjunction with other tools or for decision making. Most websites are fairly easy to use and offer downloadable data formats or allow users the option to save or print the data they find. Searchable data varies from shapefiles for ArcGIS to demographic data on specific areas, to historical maps and charts. These resources can be used to find data for adaptation planning tools, or to find local data, which is crucial for climate change adaptation planning. Data websites would be most useful in the middle of an adaptation process, likely before and while decision makers are choosing strategies for adaptation.

- **Coastal Change Analysis Program Regional Land Cover**
  http://www.csc.noaa.gov/landcover
  This tool offers land cover data sets for coastal areas that can be downloaded for free. The Coastal Change Analysis Program updates data layers every five years, helping to monitor changes in coastal habitats. Remotely sensed data is used to make the layers, with multiple dates so that users can see changes over time. Data is available for download and is in a raster format.
  Contact: The main contact is Nate Herold Nate.Herold@noaa.gov
  For support see:
  http://www.csc.noaa.gov/digitalcoast/data/ccapregional/support.html
  Questions can be directed to: nos.csc.ccap@noaa.gov
  Keywords: Land use; Land cover; Remote sensing
  Cost: None
  Training/Time Requirements: Experience working with raster data sets; No training offered through the website
  Other Requirements/Notes: None

- **Coastal County Snapshots**
  http://www.csc.noaa.gov/digitalcoast/tools/snapshots
  The Coastal County Snapshots tool provides users with a quick look at a county's demographics, infrastructure, and environment within the flood zone. A map and pull-down menus let users pick their state and county of interest (data is not available for every US county), and a report is provided for download that can be saved or printed.
  Contact: Tashya Allen, Tashya.Allen@noaa.gov
  Users can fill out a question form at:
  http://www.csc.noaa.gov/digitalcoast/feedback.html
  Keywords: Flood hazard; County-specific data
  Cost: None
  Training/Time Requirements: None

Other Requirements/Notes: None

- **Great Lakes Information Network (GLIN) Maps and GIS**
  http://www.gis.glin.net/
  This GLIN webpage offers users a number of different GIS data layers specific to the Great Lakes region. The data is downloadable in a shapefile format, and can be found by searching by topic, organization, geography, or upload date. Topics include: Biota; Boundaries/Political; Climatology/meterology/atmosphere; Elevation; Environment; Geoscientific Information; Health; Imagery/basemaps/earth_cover; Inland Waters/Hydrography; Society; Structures/Facilities; and Transportation.
  Contact: Pete Giencke, pgiencke@glc.org
  Keywords: ArcGIS; Shapefiles
  Cost: None
  Training/Time Requirements: GIS skills necessary to utilize data
  Other Requirements/Notes: None

- **Historical Maps and Charts**
  http://www.nauticalcharts.noaa.gov/csdl/ctp/abstract.htm
  Users can access this free map and chart collection, which contains thousands of maps and charts from 18th century to modern day. Featured maps include nautical charts, hydrographic surveys, topographic surveys, etc.
  Contact: Brian.Link@noaa.gov
  Or you can search for a contact to address your specific question or need at: http://www.nauticalcharts.noaa.gov/staff/contact.htm
  Keywords: Mapping; Historical data
  Cost: None
  Training/Time Requirements: Basic chart and map comprehension
  Other Requirements/Notes: None

- **MyEnvironment**
  http://epa.gov/myenvironment
  Users can enter in their zip code and receive health, air, ozone and other information specific to counties. They also have access to features like hazardous waste facilities mapping or cancer risks pie charts associated with their geographical location.
  Contact: None listed for MyEnvironment tool
  Keywords: Health; Hazards
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **New York Ocean and Great Lakes Atlas**
  http://nyoglatlas.org/
  This link leads users to the New York Ocean and Great Lakes Atlas: Data

Viewer, where users can view various data layers on New York and the Great Lakes in the area. Layer boundaries include, but are not limited to: administrative, New York State boundaries, watersheds, populations, estuaries, sewage treatment plants, and historic sites. This site is free to use and is meant to be accessed by the general public but would also be useful for government organizations, public companies, or universities.
Contact: Jeff Herter, jeff.herter@dos.state.ny.us
Keywords: Data viewer; Coastal management
Cost: Free
Training/Time Requirements: None
Other Requirements/Notes: If users need help using the data viewer, they can click on the question mark and be redirected to the help section.

- **NOAA Digital Coast**
  http://www.csc.noaa.gov/digitalcoast/
  The NOAA Digital Coast Website offers data to assist communities with coastal management issues, and provides the tools, training, and information needed to turn these data into information that is used to address timely coastal issues, including land use, conservation, hazards, marine spatial planning, and climate change. Stories are shared from around the United States, showing how the data and tools have been used successfully to manage the coasts. The website offers resources that are related to coastal management, but not all climate change related.
  Contact: Kirk Waters Kirk.Waters@noaa.gov
  You can also contact NOAA Digital Coast by filling out a question form at: http://www.csc.noaa.gov/digitalcoast/feedback.html
  Keywords: Tool acquisition; Coastal management
  Cost: None (time to search website)
  Training/Time Requirements: None (time to search website/learn about tools)
  Other Requirements/Notes: None

- **NOS Data Explorer**
  http://nosdataexplorer.noaa.gov/nosdataexplorer
  This tool is a collection of spatial information related to coastal areas and oceans, including "bathymetry, coastal maps, environmental sensitivity index maps, aerial photographs, etc." Users can download data from the site and utilize their interactive mapping tools.
  Contact: For questions, please email nosdataexplorer.noaa.gov
  Keywords: Coastal data; Database
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **Ohio Coastal Atlas**
  http://www.ohiodnr.com/AtlasGIS/tabid/19562/Default.aspx

The Ohio Coastal Atlas is a collection of resources and maps on Lake Erie and its watershed. Resources include: a digital, interactive coastal atlas; maps; GIS data; and contacts. Users can also examine a wind turbine placement viewer, a ports and harbors map, a watersheds map, and coastal erosion areas.
Contact: Brian George, brian.george@dnr.state.oh.us
Keywords: Data; Ohio; Lake Erie
Cost: Free
Training/Time Requirements: None, except may need to utilize help functions to use some of the interactive maps.
Other Requirements/Notes: None

- **Wisconsin Coastal Atlas**
  http://wicoastalatlas.net/
  This atlas provides access to maps, and other related data on Wisconsin and the Great Lakes. There are links that direct users to mapping sites like the Wisconsin County and Municipal Web Mapping Site, and maps like the Coastal Heritage Tourism Map. There are also links to spatial data layers and websites, and spatial decision tools.
  Contact: David Hart, dhart@aqua.wisc.edu
  Keywords: Wisconsin; Maps; Data
  Cost: Free
  Training/Time Requirements: None, except to utilize and download GIS data
  Other Requirements/Notes: None

Analysis Tools and Systems

The following analysis tools and systems are processes and/or software that require a moderate time investment from users in order to understand and operate the systems/tools or to carry out the method described in the system/tool. The analysis tools vary from hazard assessment systems to ecosystem restoration methods to water quality analysis tools/systems. Some require extensive computer knowledge while others are fairly user friendly. Analysis tools and systems can be used at different stages of the planning process—early on to identify hazards, or later on when decision makers are strategizing for adaptation.

- **Better Assessment Science integrating point and Non-Point Sources 4.0 (BASINS 4.0)**
  http://www.epa.gov/waterscience/basins/
  BASINS allows users to explore possible effects of climate change on watersheds and water quality. This tool combines national watershed data, GIS, modeling tools, and assessment tools into an open-source GIS system. BASINS can be utilized for a number of different purposes and can be used by local, state, and regional organizations.
  Contact: None listed; website provides a link where users can send questions to the EPA Office of Water

Keywords: Water quality; Watersheds; Modeling
Cost: None
Training/Time Requirements: 4 ½ hour day training session
Other Requirements/Notes: A basic understanding of watershed hydrology and water quality processes needed. Powerpoint lectures and exercises available on EPA website.

- **CITYgreen**
  https://www.amfor.org/productsandpubs/citygreen/
  CITYgreen analyzes ecological and economic benefits of tree canopy and other green space. Stormwater runoff, air pollution removal, carbon storage and sequestration and, landcover breakdown are all analyzed by the software. Communities can use the alternate scenario modeling feature for decision-making and planning purposes.
  Contact: info@amfor.org
  Keywords: Green infrastructure; Planning and policy
  Cost: Price varies. ($895 for commercial and government agencies)
  Training/Time Requirements: GIS proficiency
  Other Requirements/Notes: Hardware requirements: Platform PC-Intel Processor 1.0 GHz or higher, 480MB of free disk space, 1 GB memory recommended.
  Software requirements: Windows 200 or XP, ArcGIS 8 or 9 and Spatial Analyst extension
  A landcover dataset is needed for analysis and must be classified (open space, impervious surfaces, water, etc.) prior to analysis..

- **FEMA HAZUS**
  http://www.fema.gov/plan/prevent/hazus/index.shtm
  FEMA offers free HAZUS software to federal, state, and local governments to assist in risk assessment and planning for mitigation efforts. FEMA HAZUS is meant to help prevent losses associated with disasters such as earthquakes, hurricanes, and flooding.
  Contact: Program contacts:
  Eric Berman, HAZUS Program Manager and HAZUS Training and Education, Eric.Berman@dhs.govTelephone: (202) 646-3427
  Vince Brown, HAZUS User Groups (HUGs), Private Sector, E-mail: Vincent.Brown@dhs.gov Telephone: (202) 646-2725
  Phillip Moore, Emergency Management Institute and Training, Email: Phillip.Moore@dhs.gov Telephone: (301) 447-1248
  Keywords: Hazard assessment; Vulnerability assessment; Flood hazard; Disaster management; ArcGIS
  Cost: None (for HAZUS-MH 4 Version)
  Training/Time Requirements: Three day training for basic course. Additional training sessions are available for varying topics.
  Other Requirements/Notes: Hardware requirements: Pentium III 1GHz; Supporting software: ArcView 9.3 or ArcGIS 9.3.1. ArcGIS Spatial

Analyst extension required for flood model. Certification is available for professional and advanced users.

- **Habitat Priority Planner**
  http://www.csc.noaa.gov/digitalcoast/tools/hpp
  Habitat Priority Planner is an ArcGIS toolbar that helps users make decisions related to "habitat conservation, restoration, and land use planning." Users can examine various hypothetical situations through maps and reports that allow communities to make informed decisions and to more efficiently communicate possibilities.
  Contact: Bethney Ward, Bethney.Ward@noaa.gov
  Or you can also contact nos.csc.hpp@noaa.gov
  Keywords: Environmental analysis; Ecosystem restoration; Land use planning; Stakeholder engagement; Conservation
  Cost: None
  Training/Time Requirements: A one-day, instructor-led course is offered. Participants should have intermediate GIS experience
  Other Requirements/Notes: Microsoft .NET and Microsoft .NET Support for ArcGIS, ArcMap 9.2 or 9.3, Spatial Analyst. Raster or vector land cover data and other data layers required.

- **Impervious Surface Analysis Tool**
  http://www.csc.noaa.gov/isat
  This tool allows users to examine the percent of impervious surfaces in various areas, which can then be used to analyze possible water quality impacts of different management methods. This tool is meant to be an extension of ArcGIS and therefore requires that the tool be used in conjunction with ArcGIS software.
  Contacts: Dave Eslinger, Dave.Eslinger@noaa.gov
  Or Users can find a question form at:
  http://www.csc.noaa.gov/digitalcoast/feedback.html
  Keywords: Impervious surfaces; Water quality; ArcGIS
  Cost: None
  Training/Time Requirements: Varies. ArcGIS skills required
  Other Requirements/Notes: Technical specifications: Arc 9.x, Spatial Analyst, raster-based land cover data or land use grid, polygon data set and set of impervious surface coefficients.

- **i-Tree v3.0**
  http://www.itreetools.org/index.php
  I-Tree is a free software based tool that helps users quantify the benefits of trees and forests in their communities. The tool is applicable at multiple scales, ranging from a single tree to an individual forest to an entire state. Results generated from this tool can be used to help shape forest and tree management plans, involve and engage different stakeholders, among other applications. The i-tree v3.0 suite contains 5 parts: i-Tree Eco, i-Tree

Species, i-Tree Streets, i-Tree Storm, i-Tree Vue.
Contact: info@itreetools.org (i-Tree related questions)
Or you can reach the i-Tree forum at:
http://forums.itreetools.org/index.php
Phone Number: 877-574-8733
Keywords: Urban greenspace; Forest management
Cost: None
Training/Time Requirements: None
Other Requirements/Notes: A User Forum is available for users to troubleshoot; There is also an i-Tree Bug Reporting and Tracking features on the website; Customer service is available Monday through Friday via phone

- **NatureServe Vista**
  http://www.natureserve.org/prodServices/vista/overview.jsp
  NatureServe Vista is an analysis system that can help decision makes and planners make land use and planning decisions while keeping a conservation framework in mind. The software can be assist users with carrying out conservation assessments and planning projects, to help planners incorporate conservation principles in land use planning, and evaluate current and potential land use strategies. NatureServe works to incorporate a number of different, important components including "science, expert opinion, community values, and GIS." The site offers a number of support avenues for users, from user forums to sample datasets to online technical support.
  Contact: Users can visit the following website: http://www.natureserve.org/contactUs/index.jsp to find key contacts or search the NatureServe Network Staff Directory to find staff members who specialize in specific areas
  Contact: vista@natureserve.org
  Visit the following website to find a contact that fits your needs:
  http://www.natureserve.org/contactUs/index.jsp
  Keywords: Conservation; ArcGIS
  Cost: Free
  Training/Time Requirements: ArcGIS skills required; Website offers range of different training modules ranging from $150 to $200, that last from 1.5 hours to 2.5 hours.
  Other Requirements/Notes: ArcGIS required

- **Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT)**
  http://www.csc.noaa.gov/nspect
  N-SPECT is a tool that can be used to determine what effects land use changes, especially development, may have on hydrologic systems. It can also be used to examine effects on hydrologic systems from climate change. While N-SPECT can be used for various sized watersheds, it was created to mostly to examine medium and large sized watershed, but can

apply to any.
Contacts: David Eshlinger, David.Eslinger@noaa.gov
For support, go to:
http://www.csc.noaa.gov/digitalcoast/tools/nspect/support.html
Users can ask a question at:
http://www.csc.noaa.gov/digitalcoast/feedback.html
Keywords: Pollution; Watershed management
Cost: Free
Training/Time Requirements: 3 hour training
Other Requirements/Notes: Requires ESRI Arc 9.X, ESRI Spatial Analyst; Also has specific data requirements; ArcGIS experience required; Tutorial and user's manual available on website

- **Roadmap for Adapting to Coastal Risk**
  http://www.csc.noaa.gov/coastal
  This website offers a systematic approach that assists users in breaking down coastal ecosystem conservation projects into strategic and manageable steps. The approach (and website) is organized around five main components: Planning, Implementation, Performance Assessment, Adaptive Management, and Dissemination of Results. The website also provides background information on ecosystem conservation including why restoration is important and the kinds of challenges these kinds of projects may face.
  Contact: csc.info@noaa.gov
  Keywords: Coastal ecosystems; Restoration
  Cost: None
  Training/Time Requirements: Varies—No training required
  Other Requirements/Notes: None

Other Informational Websites

The following tools direct users to additional information on climate-related topics. Time investment is up to the user, as they decide which features to interact with or which additional tools to examine. These tools do not necessarily fit into a specific part of the climate change adaptation planning process, but can be used as supplemental information throughout the process.

- **Lake Superior Duluth Streams.org**
  http://www.lakesuperiorstreams.org/
  This website offers information about streams, hydrology, and water management to interested parties in Minnesota and Wisconsin. Users can find information on hydrology, including stormwater and best management practices. Most information, such as permitting requirements and data on rivers, is specific to Minnesota and Wisconsin only; however there is also valuable information for other Great Lakes residents on concepts such as inflow and infiltration, and some general management practices.

Contact: Cynthia Hagley, chagley@umn.edu
Jesse Schomberg, jschombe@d.umn.edu
Users can also submit questions and comments at the following link: http://www.lakesuperiorstreams.org/general/contactus.html
Keywords: Watershed management; Stormwater Management; Minnesota; Wisconsin
Cost: None
Training/Time Requirements: None
Other Requirements/Notes: None

- **NatureServe (Website)**
  http://www.natureserve.org/index.jsp
  The NatureServe website offers tools and data to assist users incorporate conservation into land use and natural resource planning. Users can browse current NatureServe projects, find local programs, find species and ecosystem related data, and learn about other NatureServe resources. Under the "Products & Services" heading, users can download other NatureServe tools and learn about other services NatureServe can provide.
  Contact: Users can search the contact lists at the following link: http://www.natureserve.org/contactUs/index.jsp
  Keywords: Conservation; Software; Landuse planning
  Cost: None (to browse website)
  Training/Time Requirements: None(to browse website)
  Other Requirements/Notes: None

- **NOAA Coastal Climate Adaptation**
  http://collaborate.csc.noaa.gov/climateadaptation/
  The NOAA Coastal Climate Adaptation website offers information and resources on climate change for coastal communities. Easy-to-understand climate change science information is provided, as well as examples of the various strategies communities are employing and plans and policies that have been developed to address climate change impacts. Resources can also be located using the clickable state map. Users can upload resources for their state and engage in discussions about climate-related solutions. Another feature of the website, called "Getting Started" helps communities get started on climate change adaptation.
  Contact: Stephanie Fauver, Stephanie.Fauver@noaa.gov
  nos.csc.cca@noaa.gov
  Keywords: Coastal management; NOAA; Adaptation; Climate change
  Cost: None (time to search website)
  Training/Time Requirements: None (time to search website/learn about tools)
  Other Requirements/Notes: None

- **NOAA Climate Services Portal**
  http://www.climate.gov

This website offers climate information ranging from data and services to educational materials and information. The website allows users to browse ClimateWatch articles, and offers information to educate users on climate principles. Data is available on past climatic conditions and predictions. Users can also learn how to best use climate data in their own projects.
Contacts: The following website offers users information on frequently asked questions and contacts: http://www.climate.gov/faq.html
Keywords: Climate education; Data
Cost: None
Training/Time Requirements: None
Other Requirements/Notes: None

- **NOAA State of the Coast**
  http://stateofthecoast.noaa.gov/
  This website offers information about the importance of healthy coasts, and emphasizes the interconnectedness between the economy, communities, climate, and ecosystems. Users can learn about the demographics of people living in coastal areas, details of coastal economies and ecosystems, and how climate can impact all three.
  Contacts: stateofthecoast@noaa.gov
  Get URL here
  Keywords: Coastal climate; Coastal ecosystems
  Cost: None (to browse website)
  Training/Time Requirements: None (to browse website)
  Other Requirements/Notes: None

Visualization Tools

The Visualization tools listed below help users envision effects of climate change and/or coastal development. These tools can be useful for climate change adaptation planning because they can help to visualize the effects of climate change or how adaptation measures may alter the environment. The time investment can vary by tool, as CanVis requires a fair amount of time investment for users to become familiar with the interface. However, the Visualizing Coastal Erosion and Climate Wizard websites are interactive website that do not require training and have a minimal time investment, which is dependent on the extent of reading and interacting with features on the website.

- **CanVis**
  http://www.csc.noaa.gov/canvis
  This tool assists users in visualizing potential impacts of coastal development and climate change. Users can add pictures of buildings or structures to see what visual impacts these developments may have on a larger scale. Users can play with various scenarios, such as increasing or decreasing sea levels, in order to visualize potential climate change impacts. CanVIS is not a modeling system, and therefore users may need

to base simulations on data from other models and predictions. This tool does not require extensive computer familiarity and users can upload their own photos. Users can also find images from the following website: http://www.csc.noaa.gov/digitalcoast/tools/canvis/download.html
Contact: Email Hansje Gold-Krueck, Hansje.Gold-Krueck@noaa.gov nos.csc.canvis@noaa.gov
Keywords: Coastal development; Impact visualization
Cost: None
Training/Time Requirements: 3 hour virtual training seminar, Internet and phone required; WebEx software and user instructions are provided
Other Requirements/Notes: Free technical assistance is also available

- **Climate Wizard**
  www.climatewizard.org/index.html
  This tool illustrates various IPCC climate change scenarios in the US. Users can view averages and changes in temperature and precipitation in the past 50 years and projections into the future. Resources are also available that illustrate case studies and documentation.
  Contact: Contact list on website: http://www.climatewizard.org/ContactUs.html
  Keywords: Climate change impacts; IPCC predictions
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: Public access via webpage

- **Visualizing Coastal Erosion**
  http://www.geography.wisc.edu/coastal/
  Visualizing Coastal Erosion is an interactive website that allows users to see the effects of coastal erosion in Ozaukee County, Wisconsin. Users have access to interactive exhibits that illustrate how erosion happens and depicts the change in landscape over the last 40 years, among over features.
  Contact: David Hart, dhart@aqua.wisc.edu
  Or see website for list of contacts, listed with their involvement with the project
  Keywords: Erosion; Coastal development
  Cost: None
  Training/Time Requirements: No additional training required
  Other Requirements/Notes: None

State and Regional Climatologist Contacts

Climatologists are local experts on the climate. Each state and region has their own State and Regional Climatology Centers, where climatologists have many climate related responsibilities. In their duties as climatologists, their responsibilities include: Collecting and analyzing climate related data; Communicating climate information to local communities; Helping these communities understand the importance of utilizing climate data to make decisions; Undertaking climate impact assessments; Researching climate issues and use this information to make projections. Depending on time and resources, many climatologists can also be a valuable contact in the adaptation planning process. Below is a list of regional and state climatologists and their climatology offices for Great Lakes coastal states.

- **Midwestern Region**
  Midwestern Regional Climate Center
  Contact: Steve Hilberg, hberg@illinois.edu
  Website: http://mrcc.isws.illinois.edu/

  - **Michigan**
    Michigan State Climatology Office
    Contact: Jeffrey Andreson, andresen@msu.edu
    Website: http://climate.geo.msu.edu/

  - **Ohio**
    Ohio State Climatology Office
    Contact: Jeffery Rodgers, rogers.21@osu.edu
    Website: http://www.geography.ohio-state.edu/faculty/rogers/statclim.html

  - **Indiana**
    Indiana State Climatology Office
    Contact: Dr. Dev Niyogi, dniyogi@purdue.edu
    Website: http://iclimate.org/

  - **Illinois**
    Illinois State Climatology Office
    Contact: Dr. Jim Angel, jimangel@uiuc.edu
    Website: http://www.isws.illinois.edu/atmos/statecli/index.htm

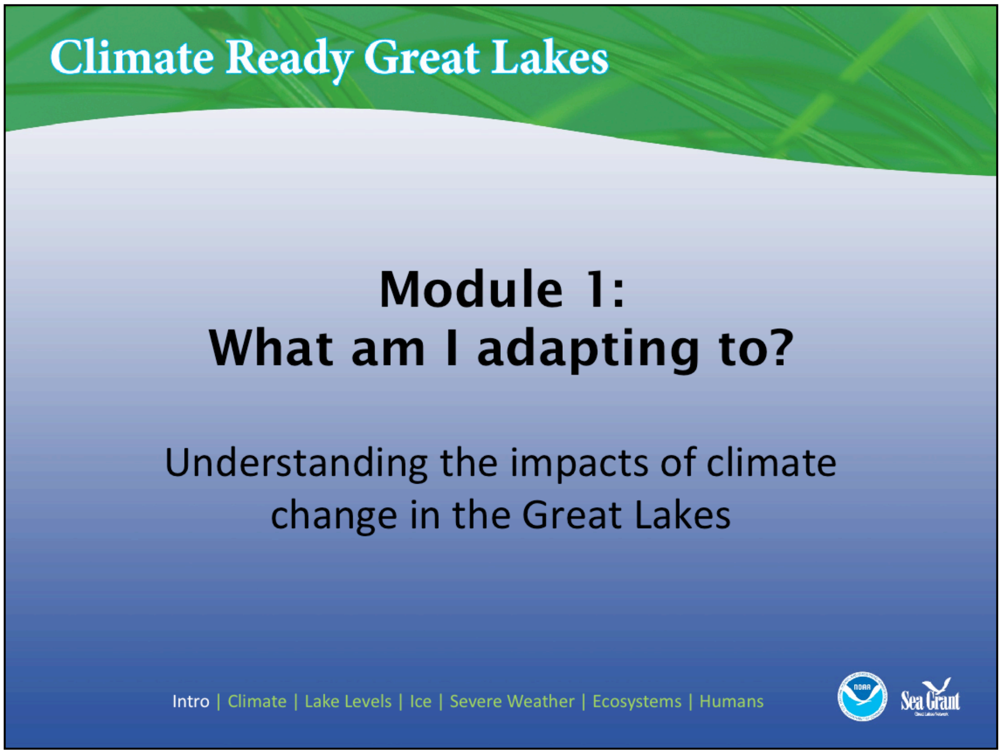
  - **Wisconsin**
    Wisconsin State Climatology Office
    Contact: John Young, STCLIM@aos.wisc.edu
    Website: http://www.aos.wisc.edu/~sco/

- **Northeast Region**
  Northeast Regional Climate Center
  Contact: Arthur DeGaetano, atd2@cornell.edu
  Website: http://www.nrcc.cornell.edu/

- **Pennsylvania**
  Pennsylvania State Climatology Office
  Contact: Paul Knight, knight@mail.meteo.psu.edu
  Website: http://climate.met.psu.edu/www_prod/

- **New York**
  New York State Climatology Office
  Contact: Mark Wysocki, nysc@cornell.edu
  Website: http://nysc.eas.cornell.edu/

Appendix 4: Module 1 Slides and Notes

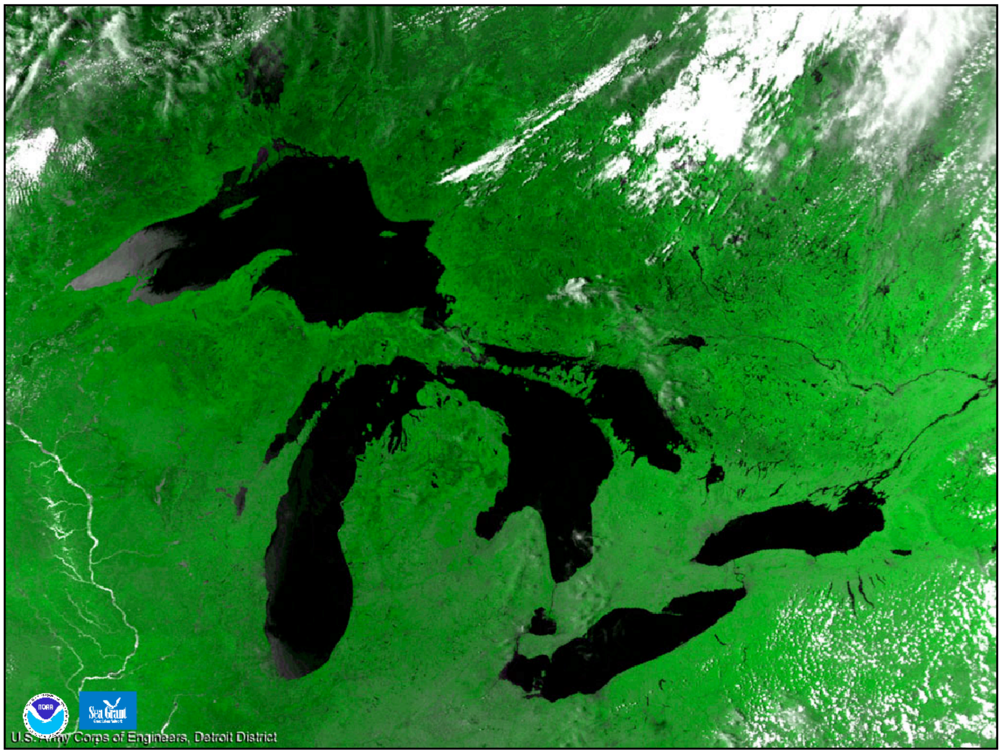


Welcome to this training on "Climate Change Impacts on the Great Lakes." This presentation is brought to you by the NOAA Great Lakes Regional Collaboration Team and the Great Lakes Sea Grant Network.

My name is X, and I will be leading the first part of today's presentation, Module 1.

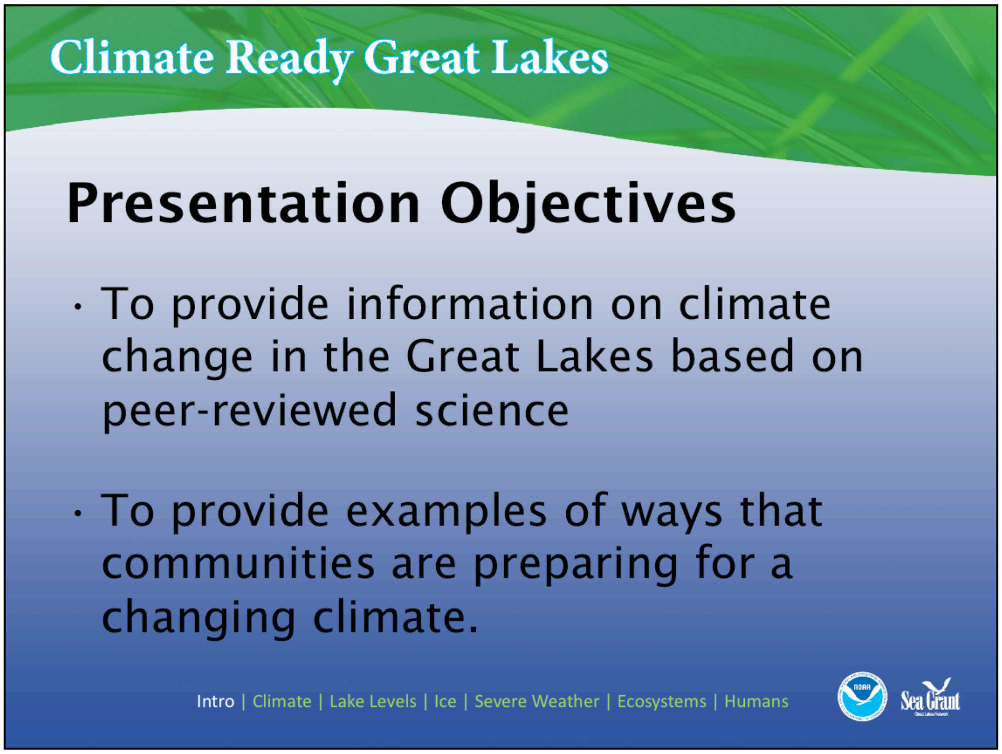
As Dr. Lubchenco points out, **(CLICK and read**… "the climate challenge before us is real…") We seem to be at a turning point in the national dialogue about climate change. It is rare that a day goes by without the media covering some aspect of climate change, whether it is a new study documenting the impacts or an editorial about how to best respond to the climate change challenge.

Within NOAA, Dr. Lubchenco is providing important leadership, sending out the message that "climate change is real, in the hopes that it will improve the capacity of individuals and communities to become climate ready.



Much of what we hear or read about, however, is about global climate change. This presentation is different. While we will discuss global climate change in the beginning of our presentation, the purpose of this training is to discuss how climate change may affect the Great Lakes region.

CLICK



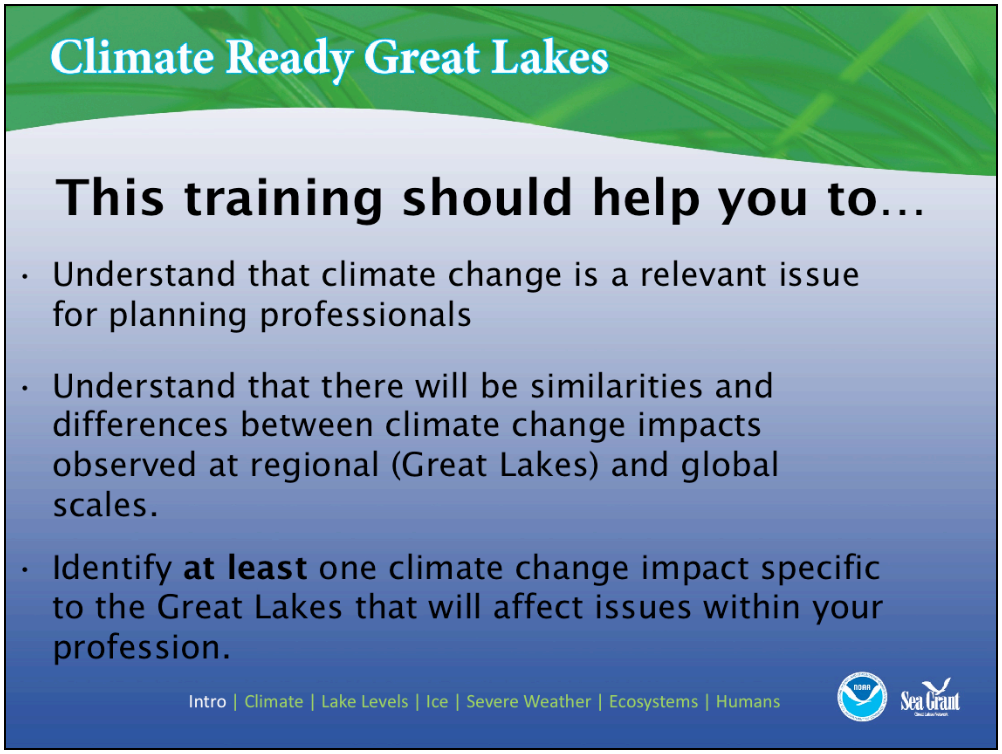
With that in mind, the goals of this training are to:

(CLICK) Provide information on climate change in the Great Lakes based on peer-reviewed science.

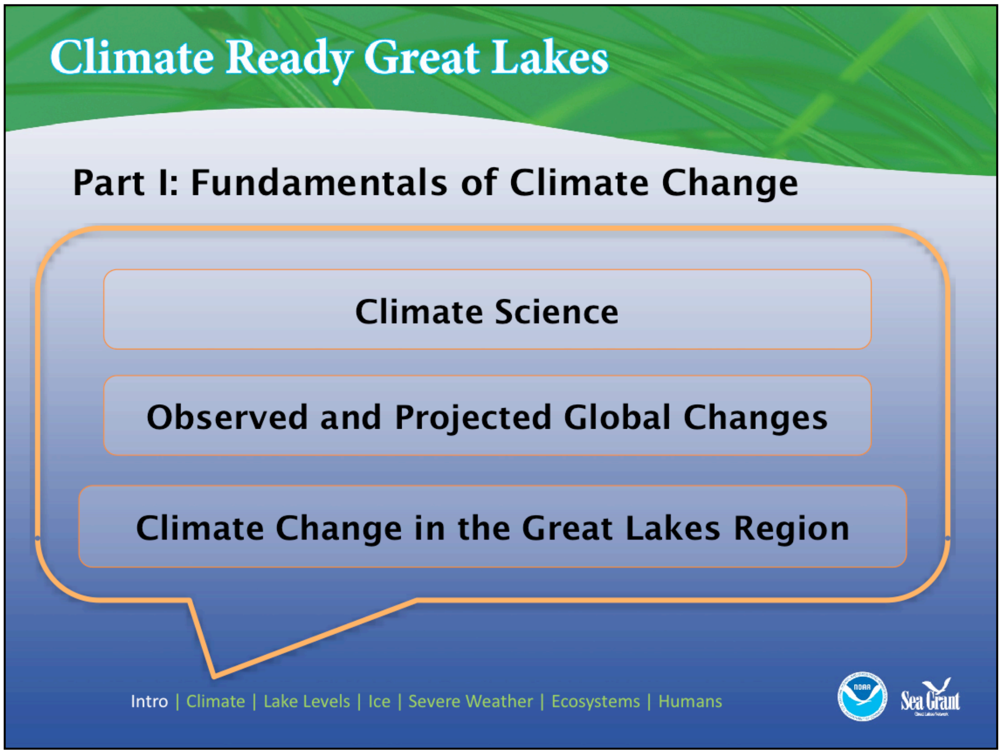
(The Great Lakes examples we describe here have all been taken from journals that subjected to the professional standards of peer review research. An annotated bibliography of these articles provides the basis for this training. We will make this bibliography available to you in handout form after the presentation.)

(CLICK) The second goal is to provide you with examples of ways that communities are preparing for a changing climate.

CLICK



This training should help you to…
READ SLIDE



Today's presentation is broken up into six interrelated sections, which are listed in the toolbar at the bottom of each slide.

Part 1 of the presentation is divided into three sub-sections that are designed to help you understand the fundamentals of climate change.

First, we'll discuss the differences between WEATHER and CLIMATE and then we'll discuss some climate science basics to help you understand the concept of climate change.

Next, we'll discuss changes that have already been observed in the earth's climate system and changes that are projected to occur.

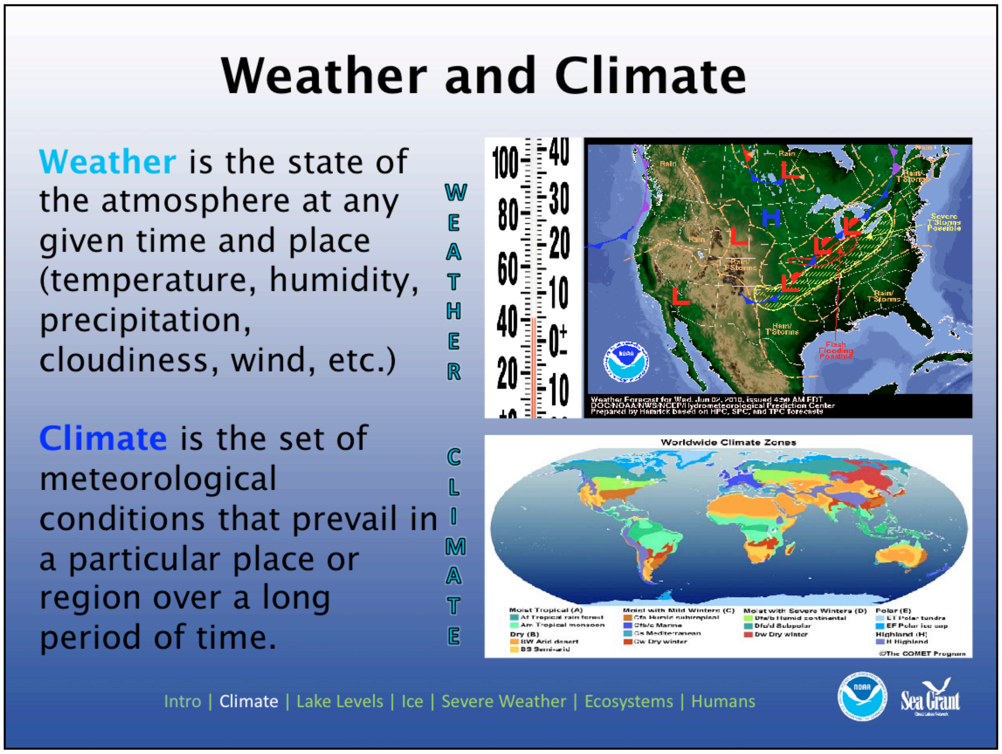
Finally, we'll discuss the Great Lakes climate as well as the projected changes for the region.

In part II of our presentation, we'll discuss in more detail how changes in the Great Lakes weather and climate system will impact lake levels, ice cover, weather patterns, ecosystems, human health and the economy.

Climate Ready Great Lakes

Part I:
Climate Science

Intro | Climate | Lake Levels | Ice | Severe Weather | Ecosystems | Humans



Before we begin discussing how climate change might impact the Great Lakes region, let’s first review the key differences between weather and climate.

An accurate understanding of the difference between weather and climate is critical to understanding the concept of climate change.

Weather is the state of the atmosphere at any given time and place (temperature, humidity, precipitation, cloudiness, wind, etc.)

Climate is the set of meteorological conditions that prevail in a particular place or region over a long period of time.

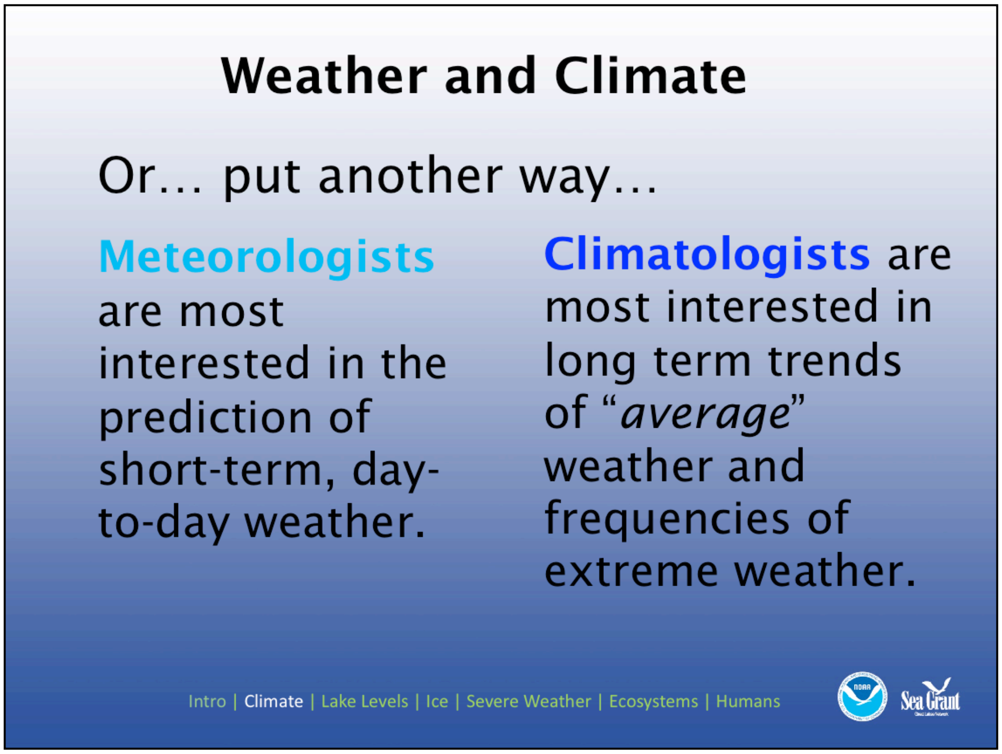
If I asked you what the weather was like today in Ann Arbor, you would tell me that it’s partly cloudy and 68 degrees. This is weather. If I were to ask you what the winter is like in Ann Arbor, you would tell me in general, it’s cold and snowy. This is climate.

Images From:

1.) Columbia Service Learning Program (CSLP) -> http://community.seas.columbia.edu/cslp/

2.) Hydrometeorological Prediction Center (HPC) -> http://www.hpc.ncep.noaa.gov/noaa/noaa.gif

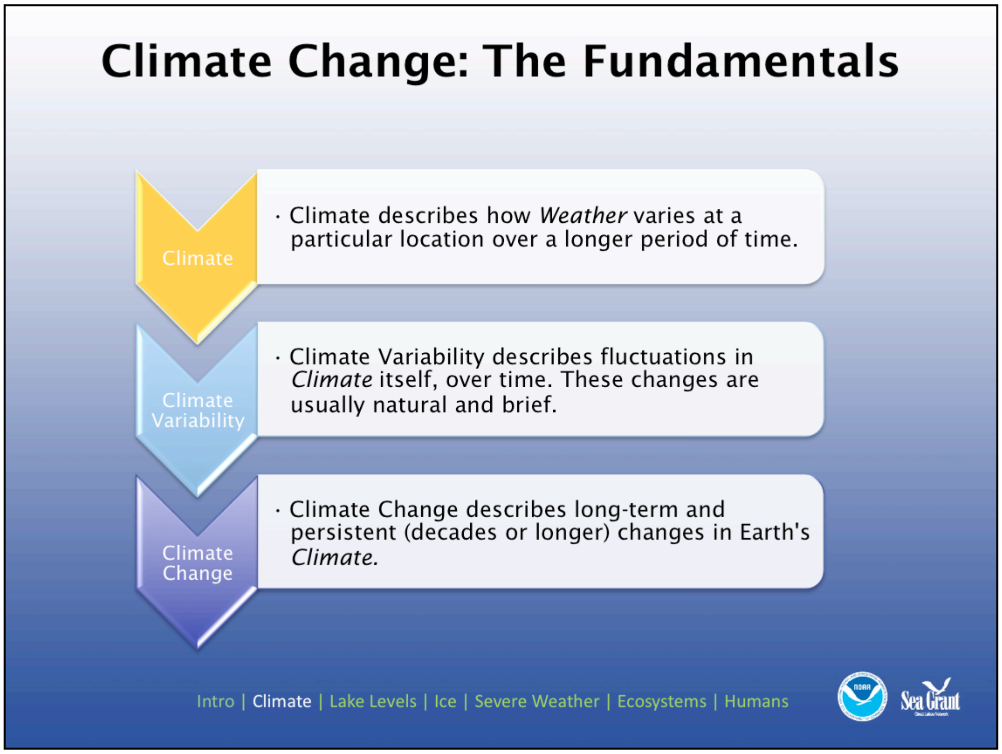
3.) COMET Program Module: “Introduction to Climatology” -> http://www.meted.ucar.edu/afwa/climo/intro/print.htm



• Weather is highly *variable* and difficult to predict beyond one week. Weather varies over hours, days, and weeks.

• Climate is less variable because it is "averaged weather" over a long period of time. Climate varies over seasons and years.

• In the graphic… the dark blue trace indicates the daily high and low temperatures throughout 2009 at Detroit. These represent the state of the weather. The light green shaded area in the middle shows the long-term (30 year) average high (top of the green) and low (bottom of the green) temperature for Detroit. This is the state of the climate. The top of the pink and the bottom of the purple represent record highs and record lows. You can there are a few times per year that we approach or exceed record high or low temperatures.

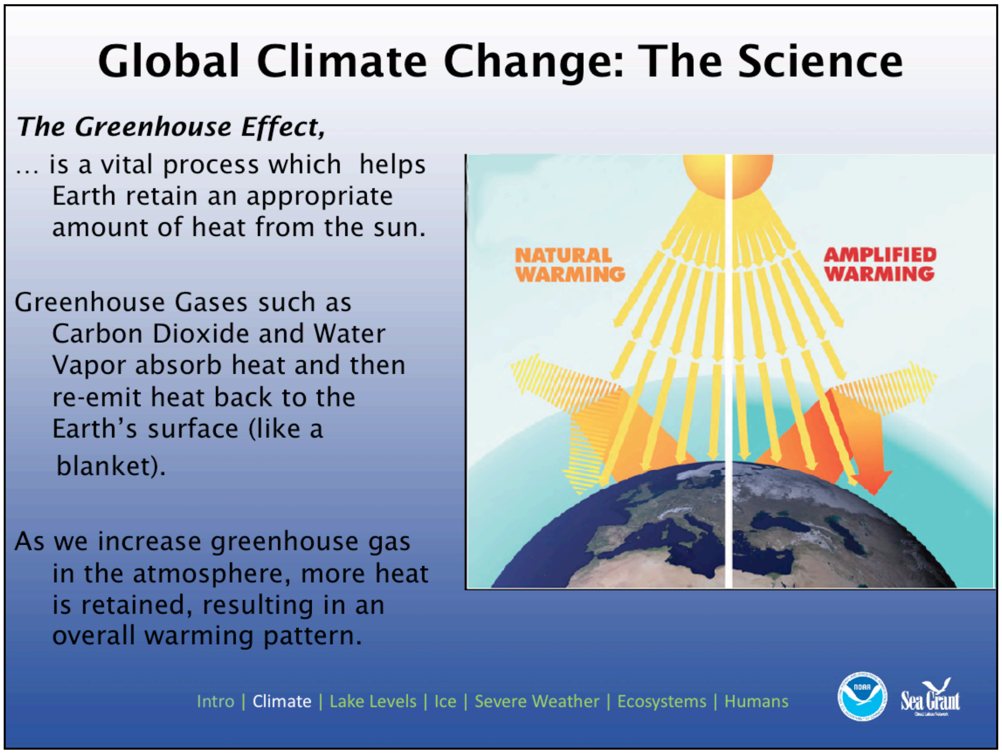


So to summarize…

Climate describes how *Weather* varies at a particular location over a longer period of time.   In other words, it's the average of all the weather spread over a long period of time. "Normals" are derived from averaging the weather.

Climate variability describes changes in *Climate* itself, with time. Such changes are usually natural and of a brief timescale.

Climate Change describes longer-term and persistent (decades or longer) changes in Earth's *Climate*. This may be described as persistent or permanent changes in the "Normals".



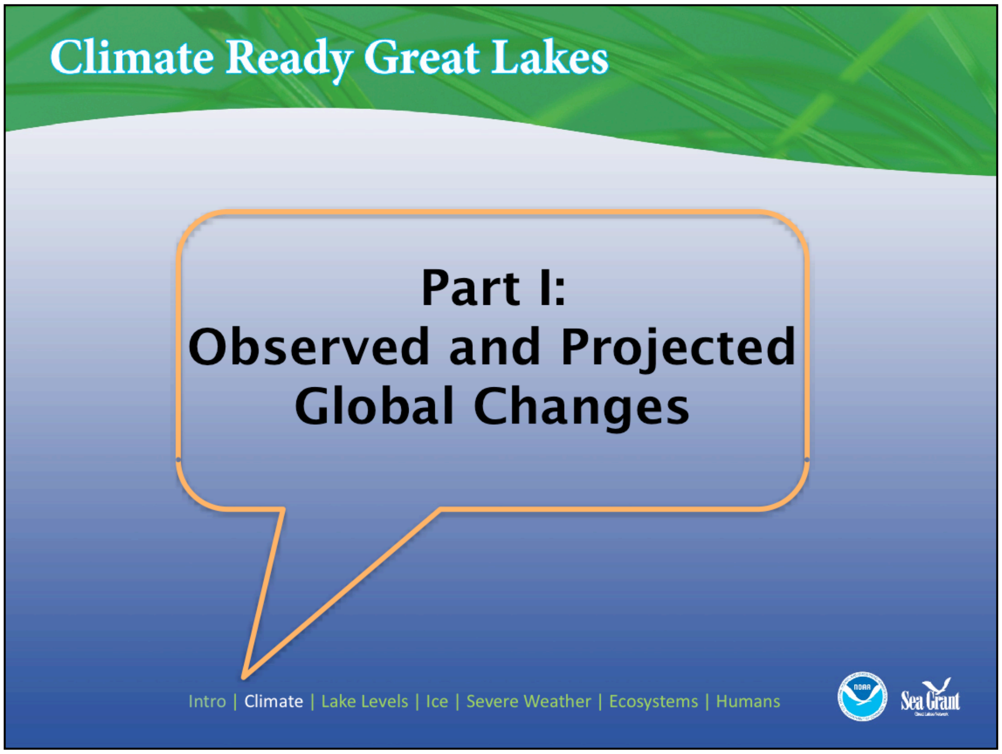
Now that you can distinguish between weather and climate, the next part of our presentation will focus on the observed changes in global climate.

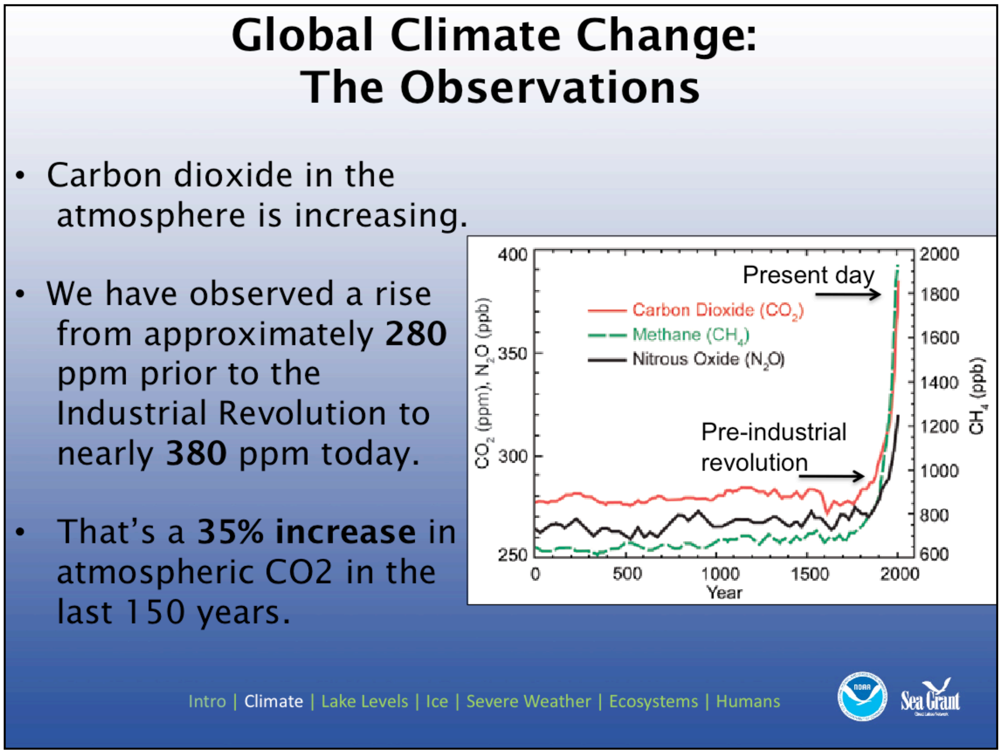
The Greenhouse Effectis a vital and healthy planetary process which helps the Earth retain heat from solar radiation. With an increase in the amount of Greenhouse Gases emitted into the atmosphere, an excessive amount of heat is retained, and less energy is able to escape Earth's atmosphere. In this way, excessive Greenhouse gases act like an atmospheric blanket. Thus, Earth's surface heats up more quickly, creating an overall increase in the earth's temperature.

We know that increased human emissions of greenhouse gases are causing global climate change. Carbon dioxide and other pollutants collect in the atmosphere and trap the sun's heat, gradually warming the planet.

In the U.S., coal-burning power plants are the largest source of carbon dioxide pollution -- they produce 2.5 billion tons every year. Automobiles, the second largest source, create nearly 1.5 billion tons of carbon dioxide annually. In short, human emissions have amplified this natural thermal process.

Source: http://www.nps.gov/grba/naturescience/what-is-climate-change.htm


Climate Ready Great Lakes
Part I:
Observed and Projected Global Changes
Intro | Climate | Lake Levels | Ice | Severe Weather | Ecosystems | Humans
Sea Grant



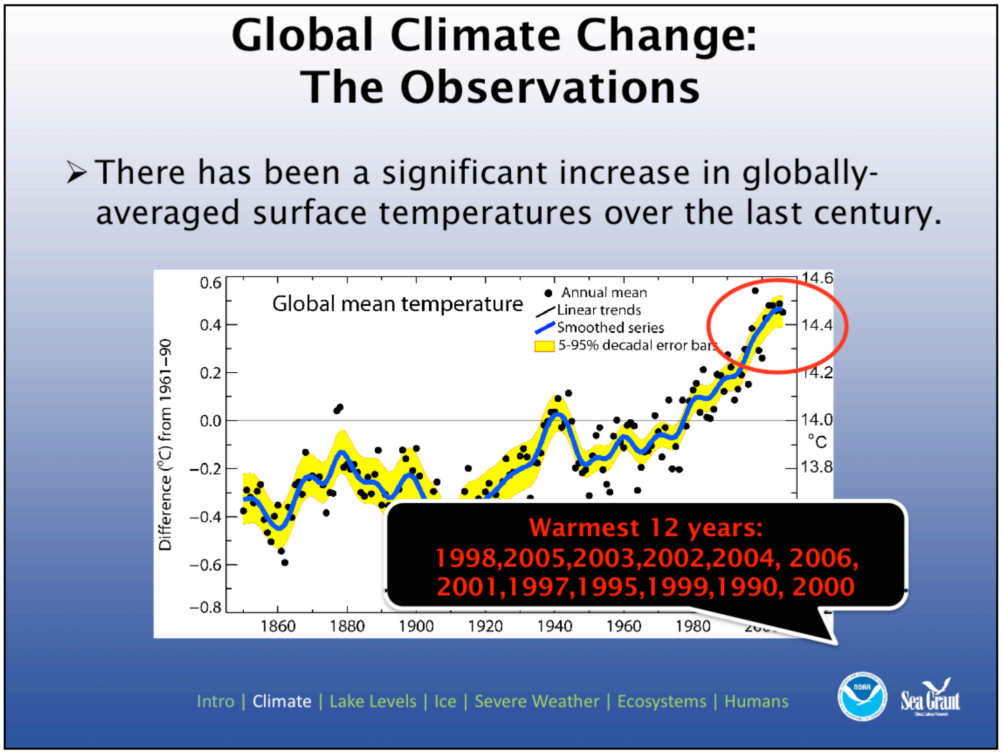
So how do we know that human activity is amplifying the earth's greenhouse effect?

- Carbon dioxide in the atmosphere is increasing.

- We have observed a rise from approximately 280ppmv prior to the IndustrialRevolution to nearly 380 ppm today.

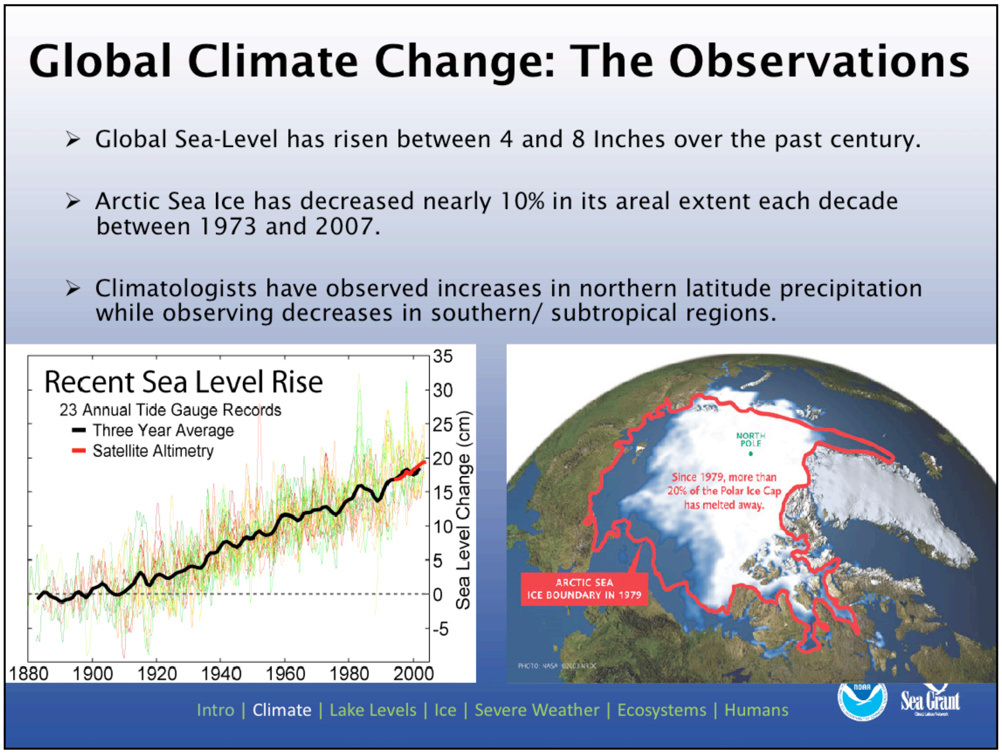
- That's a 35% increase in CO2 emissions over the last 150 years.

Source: IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.



Coincident to these observed increases in atmospheric CO_2, we have observed an increase in global average surface temperatures, with the Earth having warmed approx. 1˚ Celsius (or 1.8˚ Fahrenheit) since the beginning of the industrial revolution. In the last 150 years, the warmest twelve years have been observed from 1990-2006.

Source: Intergovernmental Panel on Climate Change, 4th Assessment Report



Along with an increase in global average temperatures, scientists have also observed significant changes in sea level and arctic ice over the last century.

- Global Sea-Level has risen between 4 and 8 Inches (or 10-20 cm) over the past century.
- Arctic Sea Ice has decreased nearly 10% in its areal extent each decade between 1973 and 2007. In fact, arctic sea ice coverage was at a record low in 2010.
- Climatologists have observed increases in northern latitude precipitation and decreases in subtropical regions.

Aim: This slide aims to present realities of Global Climate Change, meaning changes which have already occurred.

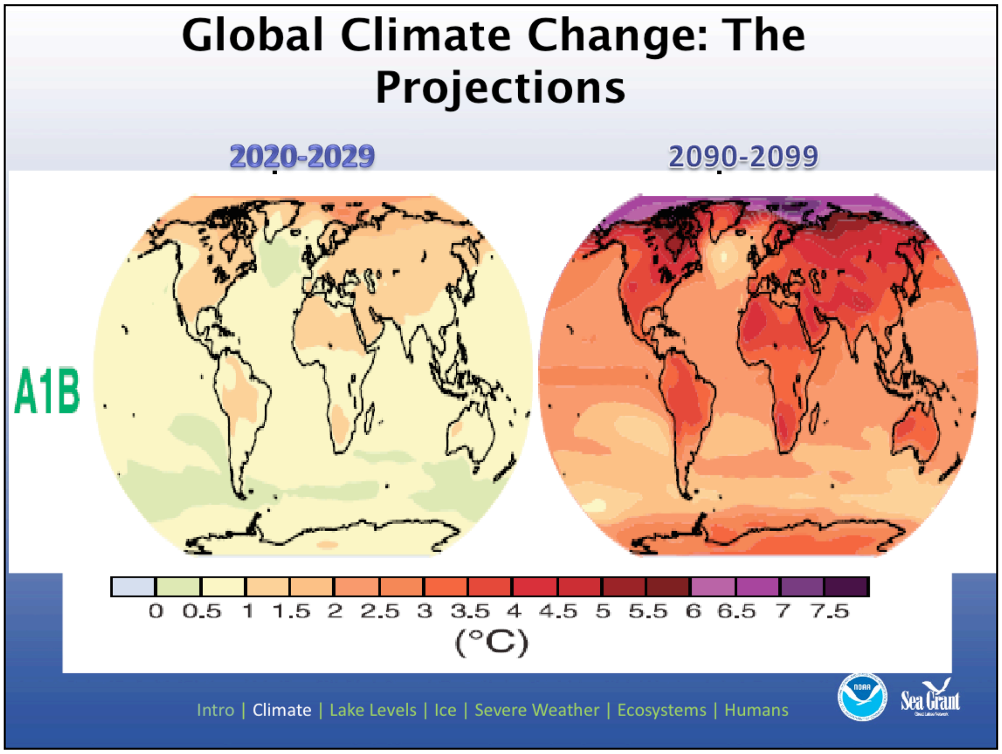
Key Points: This slide is fairly self-explanatory as it is just a list of consequences which our planet has already experienced as a result of GCC. Different from forecast or projected changes, this list of changes is already a reality; and so, it is not necessary to emphasize uncertainty here.

Figures: There are 2 figures in play here. The first figure depicts recent rises in Sea Level, with the colored area depicting various measurements, and a black/red line representing a consensus. Finally, the last figure depicts recent reductions in Arctic Sea Ice coverage. Essentially, it is self-explanatory.

Source:

Recent Sea Level Rise image: http://astro.wsu.edu/worthey/astro/html/lec-climate.html

Arctic Sea Ice: http://www.nrdc.org/globalwarming/images/



So what do scientists think might result from continued global climate change?

Given an average of global carbon dioxide emissions scenarios…

> ➢ Northern latitudes will *likely* continue to become wetter while subtropical locations *likely* grow even drier. The map shows likely warming by 2020-2029 as well as by 2090-2099. Notice, northern latitudes are *likely* to experience a greater degree of warming. The "A1B" is simply the IPCC's code for its "middle" ground emissions scenario.

Figure:

This figure is a map of likely warming by 2020-2029 as well as by 2090-2099. Notice, northern latitudes are likely to experience a greater degree of warming. The "A1B" is simply the IPCC's code for its "middle" ground emissions scenario.

Aim: This slide aims to present projections of Global Climate Change, meaning changes which are forecast to occur.

Key Points: This slide is meant to convey that different regions of the globe will experience different impacts with northern latitudes experiencing different conditions than subtropical locations.

Graphics: The word "likely" is in bold print in order to underscore how important it is to account for scientific uncertainty.

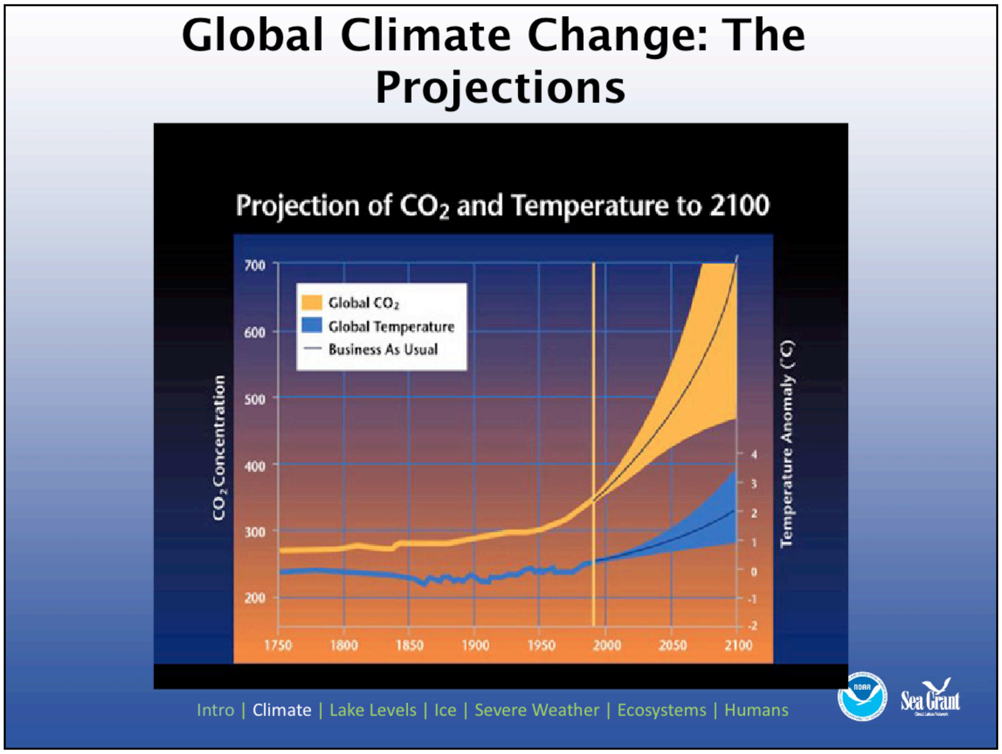
Source:

1.) Intergovernmental Panel on Climate Change (IPCC) ->

http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

2.) Columbia Univ. Earth Institute ->

http://www.ldeo.columbia.edu/edu/dees/V1003/images/projected.CO2.temp.jpg



Moreover…

➢Globally-averaged surface Temperatures will *likely* increase 1.8-4 degrees Celsius by 2100, with greater increases at northern latitudes. This graphic depicts likely increases in Carbon Dioxide concentrations by 2100 along with projected Temperature increases given such Carbon Dioxide levels ("business as usual").

➢Due to this, Arctic Sea ice coverage is also *likely* to decrease even further than was discussed previously, from approximately 7 million sq. kilometers to 4 million sq. km and *likely* sea-level rises of .6-1.9 feet over the next century.

This figure is a graph that depicts likely increases in Carbon Dioxide concentrations by 2100 along with projected Temperature increases given such Carbon Dioxide levels ("business as usual").

Aim: This slide aims to present projections of Global Climate Change, meaning changes which are forecast to occur.

Key Points: CO2 and temperature increases have been observed to increase in parallel with one another.

Graphics: The word "likely" is in bold print in order to underscore how important it is to account for scientific uncertainty.

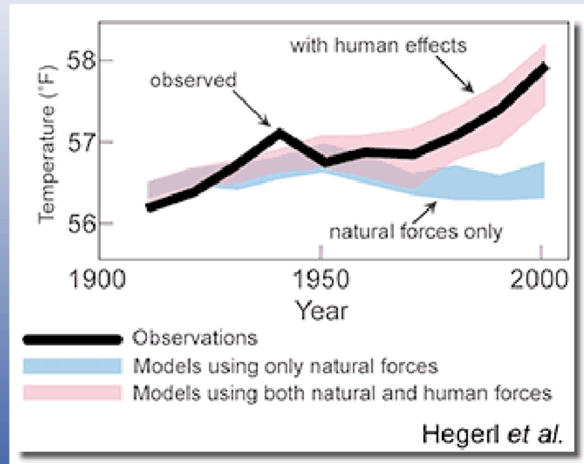
Source:

1.) Intergovernmental Panel on Climate Change (IPCC) ->
http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

2.) Columbia Univ. Earth Institute ->
http://www.ldeo.columbia.edu/edu/dees/V1003/images/projected.CO2.temp.jpg

A Valuable Tool: Climate Models

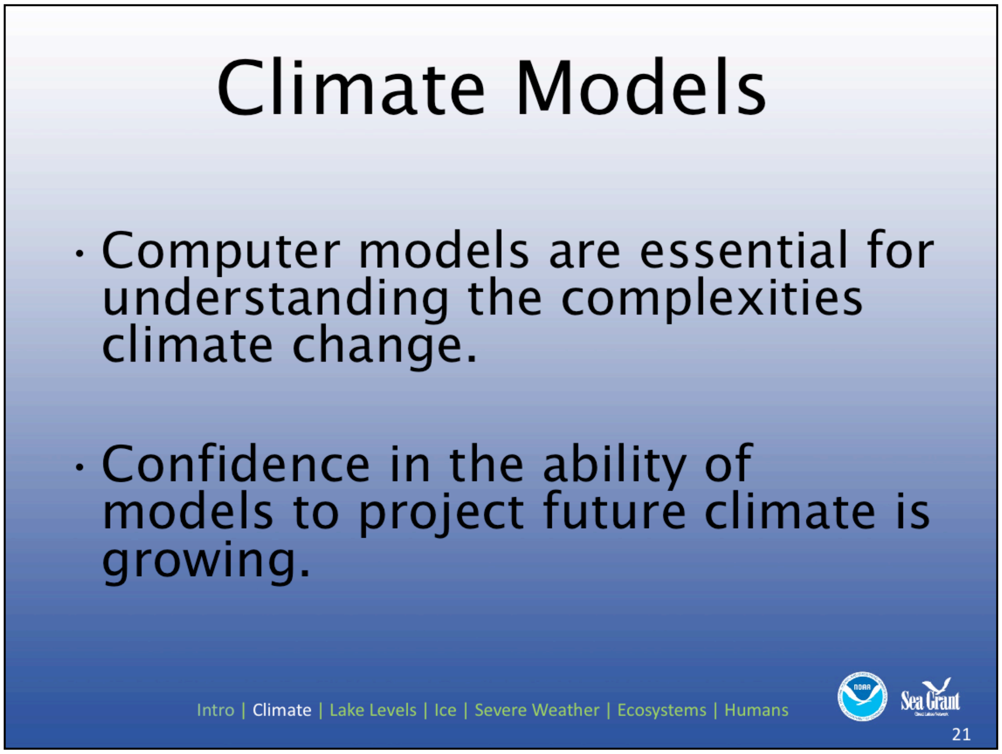
Climate models give additional clues concerning how human forces contribute to climate change.



Intro | Climate | Lake Levels | Ice | Severe Weather | Ecosystems | Humans

Using climate models, scientists have been able to demonstrate how increases in global average surface temperatures are not just a result of natural forcing.

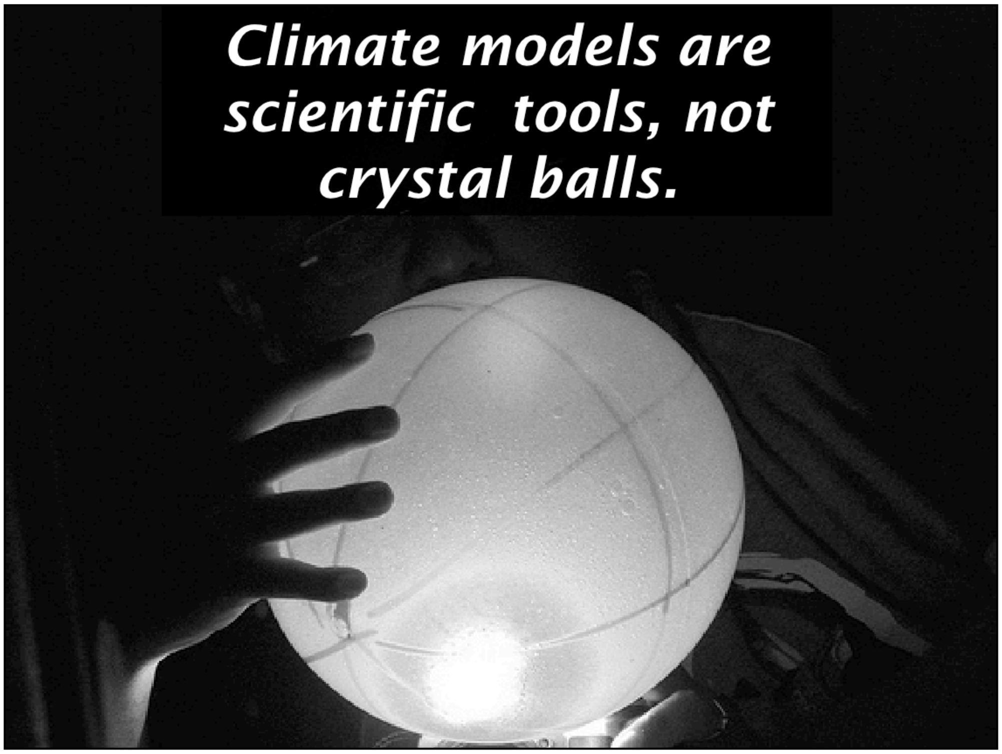
Source: Hegerl, G. C., F. W. Zwiers, and P. A. Stott, and V. V. Kharin, 2004: Detectability of anthro- pogenic changes in temperature and precipitation extremes. J. Climate, 17, 3683–3700.



Global Climate Models also help us understand and quantify degrees of uncertainty associated with climate change forecasts.

Climate Change uncertainties include questions regarding the degree of future Greenhouse Gas emissions, solar output, and variations in ocean circulation patterns and the complexities of the interactions between such variables.

Our confidence in the ability of models to project future climate is growing.



This figure is a bit complicated at first glance; however, it is simply a depiction of what a model's "innards" look like, so to speak.

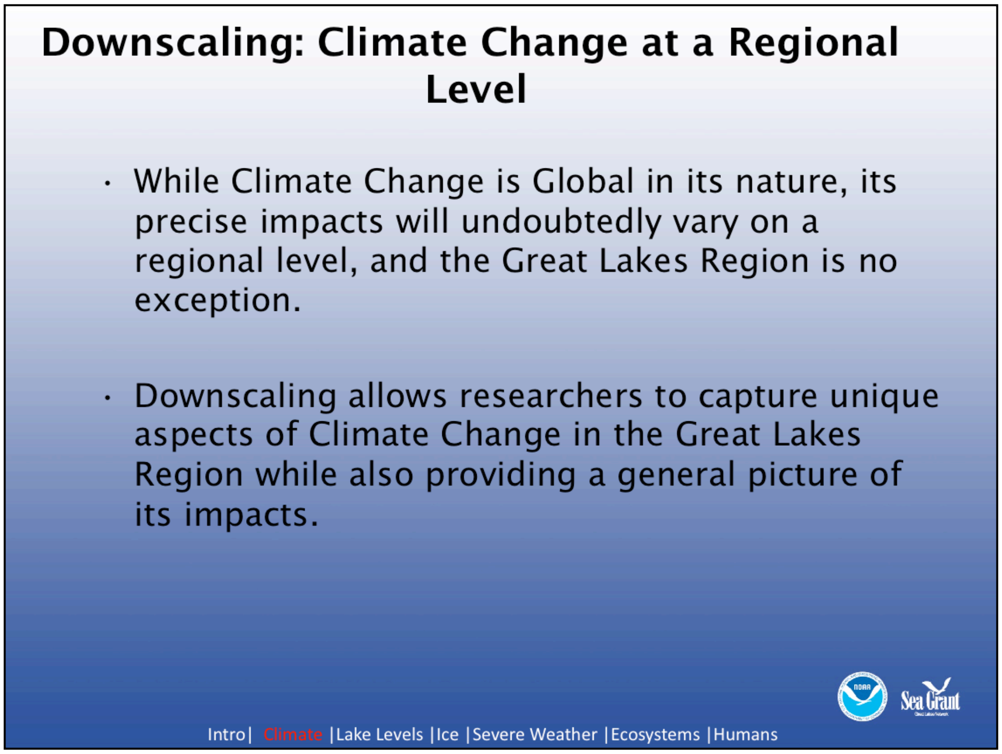
Understanding, as well as predicting something as complex as the climate, is not done with a simple hypothesis. Models simulate the physical,chemical and earth processes that drive climate. Models are used to study past changes in the earth's climate, as well as project future changes.

These models are our best, collective guess as to how the climate system works, based on past and current observations, tested against historic and prehistoric conditions using data records from the past.
CLICK

It is important to understand that climate models are scientific tools, not crystal balls. They are, however, critical tools that are used by decision makers and planners to build our communities for the future.

CLICK

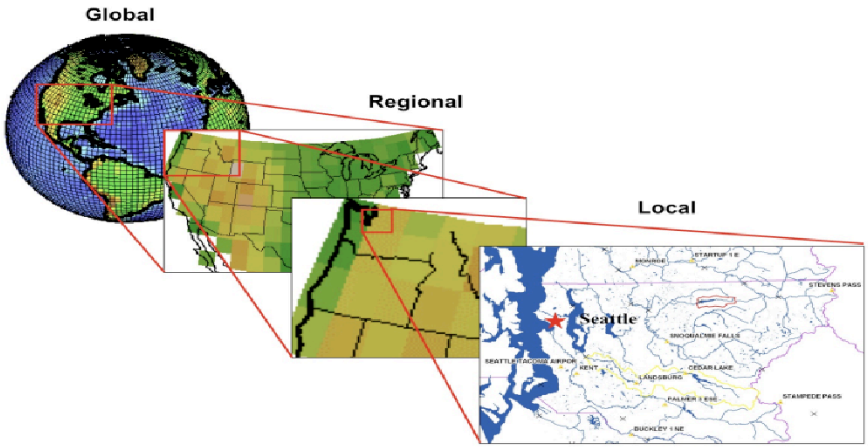
Image Source: http://www.flickr.com/photos/shubhrajit/2871326329/



Downscaling is a process of progression from a broad scale (in this case, global or perhaps, national) to a narrower scale (such as a regional or local scale). In the case of Climate Change, researchers are taking predictions made by Global Climate Models and extracting statistical information on a regional or even local scale.

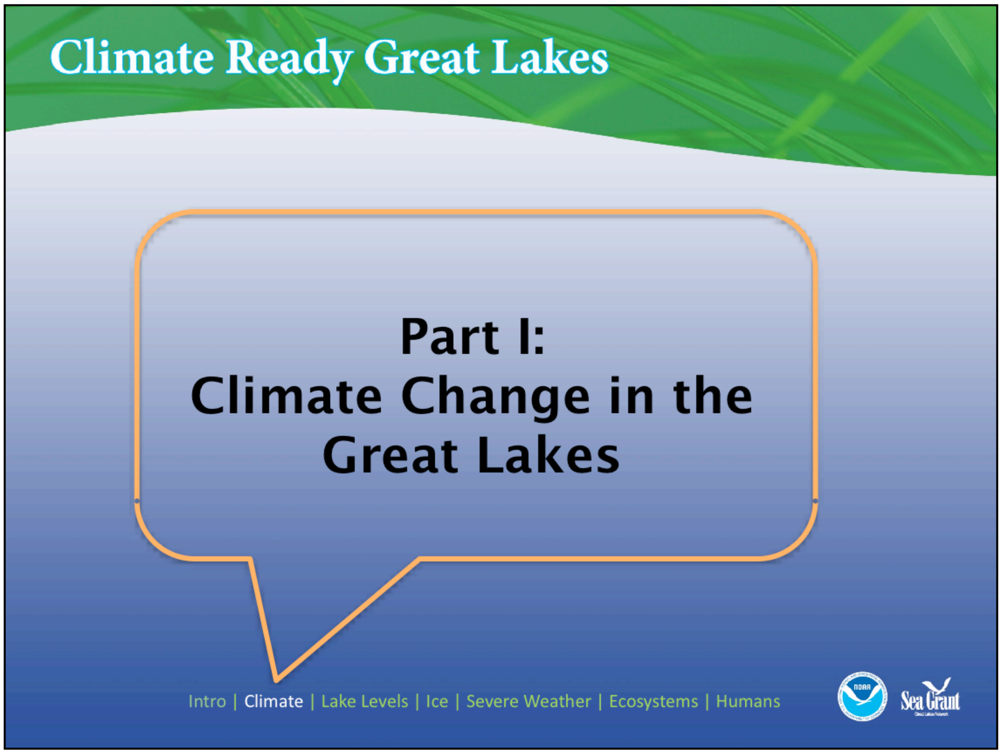
http://ccr.aos.wisc.edu/model/ipcc10min/futclimateinfo.html

Downscaling: Climate Change at a Regional Level

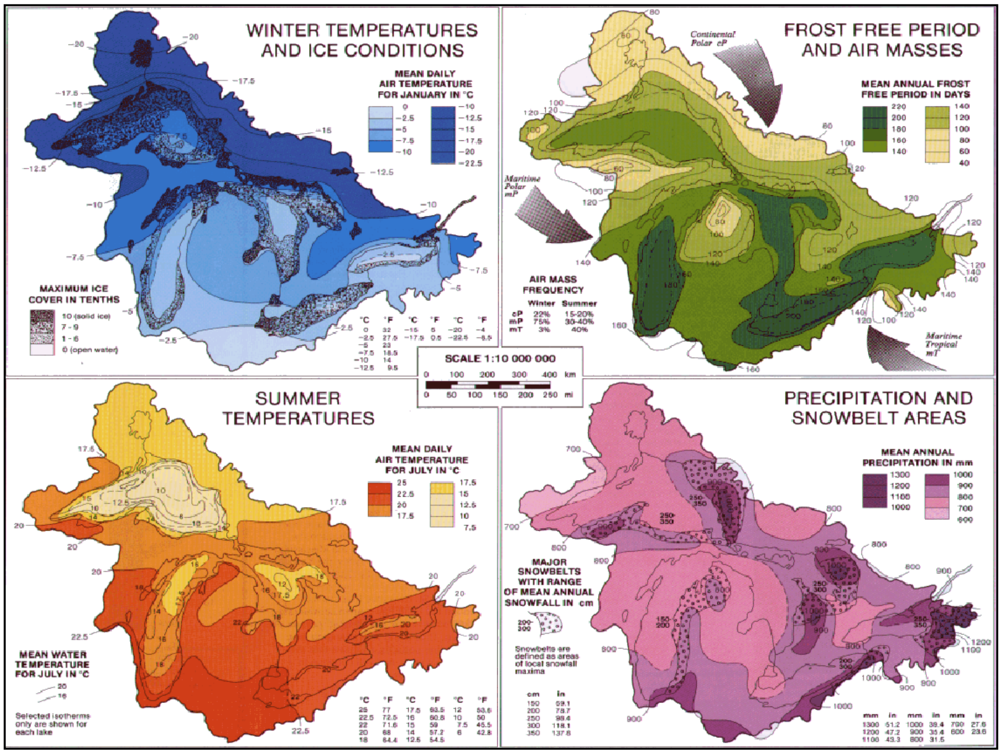


Why do we have to downscale global climate information to the regional scale? Global models don't have the resolution to handle things like mountains and valleys, or lakes that have impact on local and regional climates. Thus, the larger global climate projections must be adapted (statistically) to account for the presence of these features.

Although scientists are increasingly moving towards the use of regional climate models for climate projections - many of the impacts in this presentation use climate scenarios based on global models.



So what makes climate change impacts in the Great Lakes region different from **GLOBAL** climate change impacts?



What it really comes down to is the fact that we have a unique and diverse climate, influenced by its location in the middle of a large land mass (North America), and the presence of the Great Lakes. The Great Lakes are about 84% of the surface freshwater resources in the United States and they have 10,000 miles of coastline. So let's talk a little about *how* lake effects influence the region's climate system…

The Great Lakes have a big influence on the climate. Acting as a giant heat sink, the lakes moderate the temperatures of the surrounding land, cooling the summers and warming the winters. This results in a milder climate in portions of the basin compared to other locations of similar latitude. The lakes also act as a giant humidifier, increasing the moisture content of the air throughout the year. In the winter, this moisture condenses as snow when it reaches the land, creating heavy snowfall in some areas, known as "snow belts" on the downwind shores of the lakes. The shores of Lake Superior are prone to this "lake effect" snow and have recorded up to 350 inches of snow in a single year. During the winter, the temperature of the lakes continues to drop. Ice frequently covers Lake Erie but seldom fully covers the other lakes.

We can see evidence of how the presence of the lakes impacts…

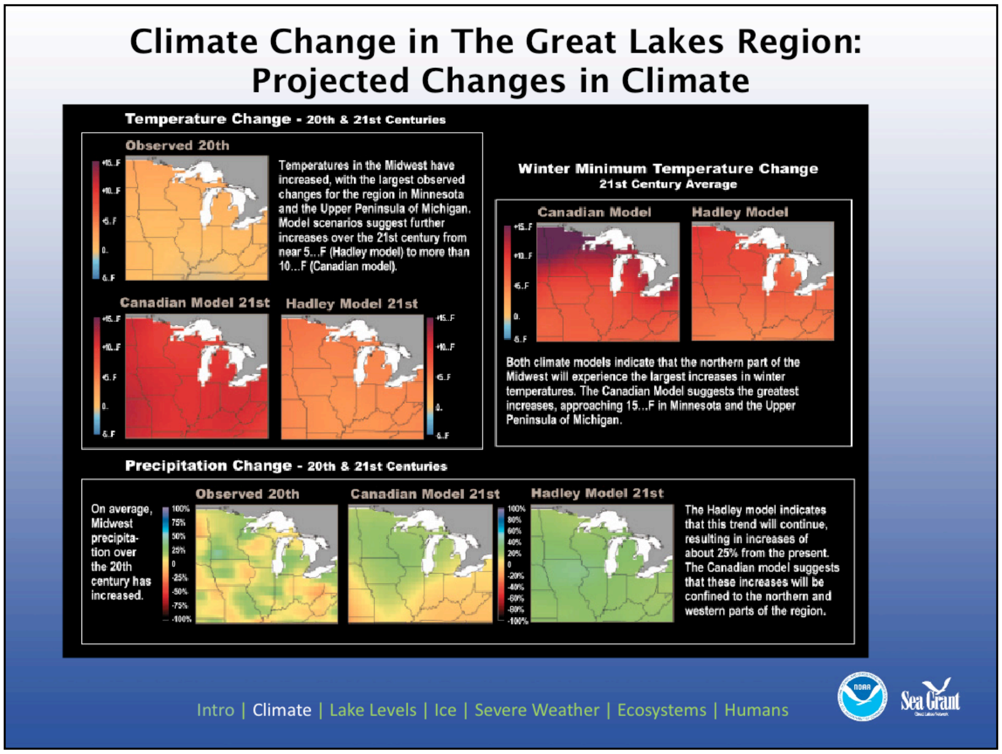
1. …temperature climate in most areas (particularly east and south of the lakes where its generally warmer in the winter and summer- point to temperature along east and southern edges of the winter and summer slides. Notice how the southern shore of Lake Superior is cooler than the land mass just south of it in the winter and warmer than the land mass north of it in the summer.

   ON WINTER SLIDE: In the winter, most lakes remain ice-free except Erie (the shallowest of the lakes).

1. … the length of the growing season along the shorelines (point to frost free map to demonstrate how closer to shore there is longer growing season- the lakes moderate the temperature around the shore.

2. …and heavy snow bands in winter along the eastern and southern shorelines. They can even reduce summer precipitation downwind of the shore due to stabilizing lake breeze effects (point to precipitation and snow belts and show how the air masses shown in the frost free image impact snowfall in the eastern and southern shoreline).

Source: Great Lakes Atlas, Environment Canada and U.S. Environmental Protection Agency, 1995



Using climate models, scientists have made the following projections about changes in the Great Lakes CLIMATE…

- Average surface Temperatures are *likely* to rise another 3 to 6 degrees Celsius or 5-10 degrees Fahrenheit by 2100.

- Annual (yearly) average precipitation is *likely* to become increasingly unevenly distributed. In fact, the USGCRP predicts likely increases of 10-30% in wintertime precipitation and likely decreases of 5-25% in summertime precipitation.

- While annual average precipitation may increase slightly, lake levels could potentially drop as a result of increased evaporation, owing to warmer temperatures.

- Lake ice coverage is also *likely* to drop as we head deeper into the 21st century.

Aim: The aim of this slide is to discuss Projected Impacts of Climate Change in The Great Lakes Region. Now, it is important to recognize this slide is focusing on climatological impacts. Thus, we are talking about increases in average temperatures, average precipitation, and average lake levels/ice coverage.

Key Points: The key to this slide lies in pinpointing Projected Impacts of Climate Change over The Great Lakes Region. Said impacts are likely to occur; and thus, it is necessary to emphasize uncertainty in a more direct manner. Also, this slide offers four bullets, each of which lists a distinct impact of Climate Change and a related figure which compliments each point (in-depth discussion below).

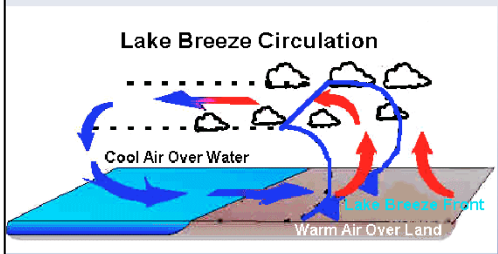
Figures: The above figure is an excellent snapshot of Projected Impacts, which Climate Change portends to instigate in The Great Lakes Region. It offers excellent maps which depict likely Temperature and Precipitation Changes. Specifically, it directly relates to two of the four points discussed (shifts in both Temperature and Precipitation) and indirectly explains both decreased water levels (increased evaporation results from warmer Temperatures) and decreased lake ice coverage (lake ice will not form as easily as average wintertime Temperatures rise, especially minimum Temperatures). Furthermore, it is relatively easy to understand as well. The only point which might seem a bit confusing surrounds its depiction of projections from both the Canadian and Hadley models. However, it is simply important to remind our audience of the fact that no projection is set in stone, and different models help us to get a feel for the "range" of possibilities, which exist.

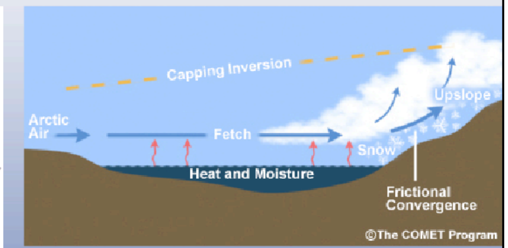
Graphics: As in earlier slides, the word "likely" is typed in bold print in order to emphasize uncertainty's importance.

Images From:

1.) United States Global Change Research Program (USGCRP) -> http://www.usgcrp.gov/usgcrp/Library/nationalassessment/LargerImages/RegionGraphics/Midwest/MWClimate.jpg

The Impact of the Great Lakes on Regional Climate Change





Lake breeze circulations in summer keep shoreline areas cooler compared to surrounding inland areas.

Lake effect precipitation may become increasingly common in late fall and winter as cool wintertime air flows over warm lake waters.

Intro | Climate | Lake Levels | Ice | Severe Weather | Ecosystems | Humans

While the Great Lakes Region is likely to experience changes as a result of Climate Change, (CLICK) in what ways might *the Great Lakes* themselves influence potential climate impacts?

• The Great Lakes gain and lose heat more slowly when compared to surrounding land masses. (CLICK)… (Explain Lake Breeze Circulation diagram… warm temperatures over land rise and are cooled. A lake breeze front pushes the air up and over the lakes. Cooler air is blown off the lake toward the shore, cooling temperatures along the shoreline. This will not change in light of broader scale, climatic changes; however, it will have some important effects.

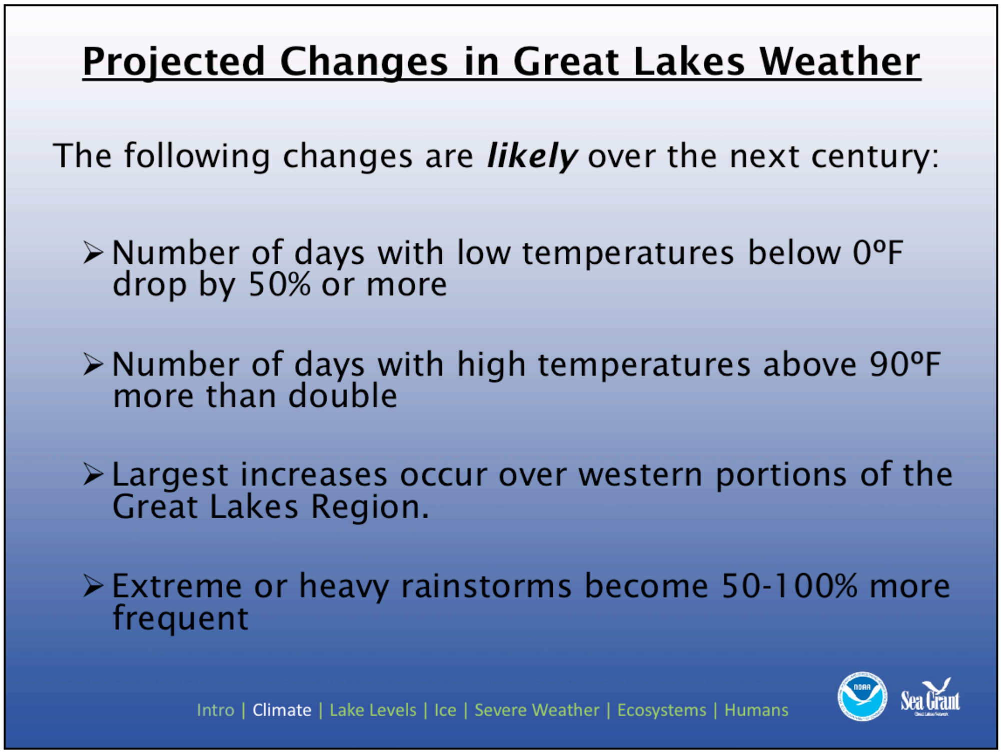
• On a positive note, summer temperature increases will *likely* be less severe downwind of The Great Lakes as a result of lake-induced cooling.

• This could make parts of the region more appealing for summer tourism – and a place to “escape the heat”.

• An increased difference between air and water Temperatures in fall and early winter will *likely* lead to an increase in “lake-effect” precipitation. (Graph on right: Warmer summer temperatures heat up the lake in the summer. In winter, cold air across the warmer lake results in lake-effect precipitation.

• As lake ice coverage decreases, the Union of Concerned Scientists predicts a “cultural shift” may occur as wintertime recreation held on previously frozen lakes becomes more difficult.

• These are simply examples of how weather, climate and the lakes interact with each other.



So, how will Climate Change interact with the lakes to alter daily WEATHER patterns over The Great Lakes Region? It's important to note that now we are talking about daily or weekly conditions as opposed to the average changes mentioned in the previous slide.

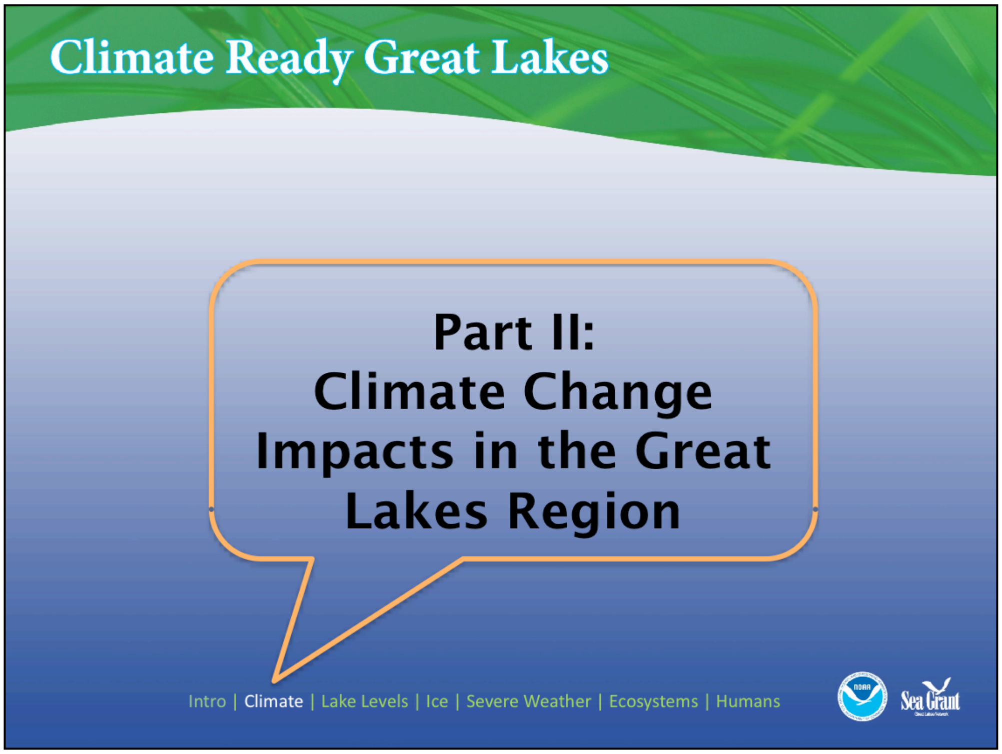
READ FROM SLIDE

Slide Notes:

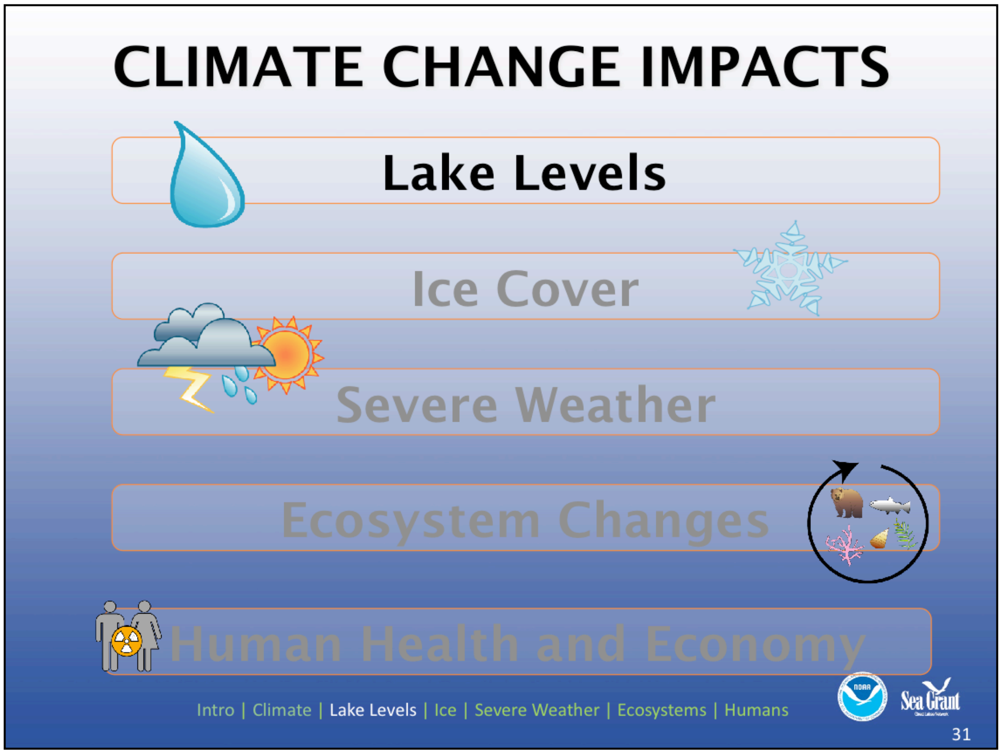
Aim: This slide aims to summarize conditions which might become more prevalent over The Great Lakes region as Climate Change continues to play out. (now, we are talking about daily or weekly conditions as opposed to the averages indicated in the previous slide)

Key Points: The key to this slide is to begin by briefly reviewing the distinction between Weather and Climate in order to separate this slide from Slide 12. Secondly, it is once again important to emphasize scientific uncertainty by describing projected impacts as being likely to occur.

Source: IPCC, 2001: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Soloman, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

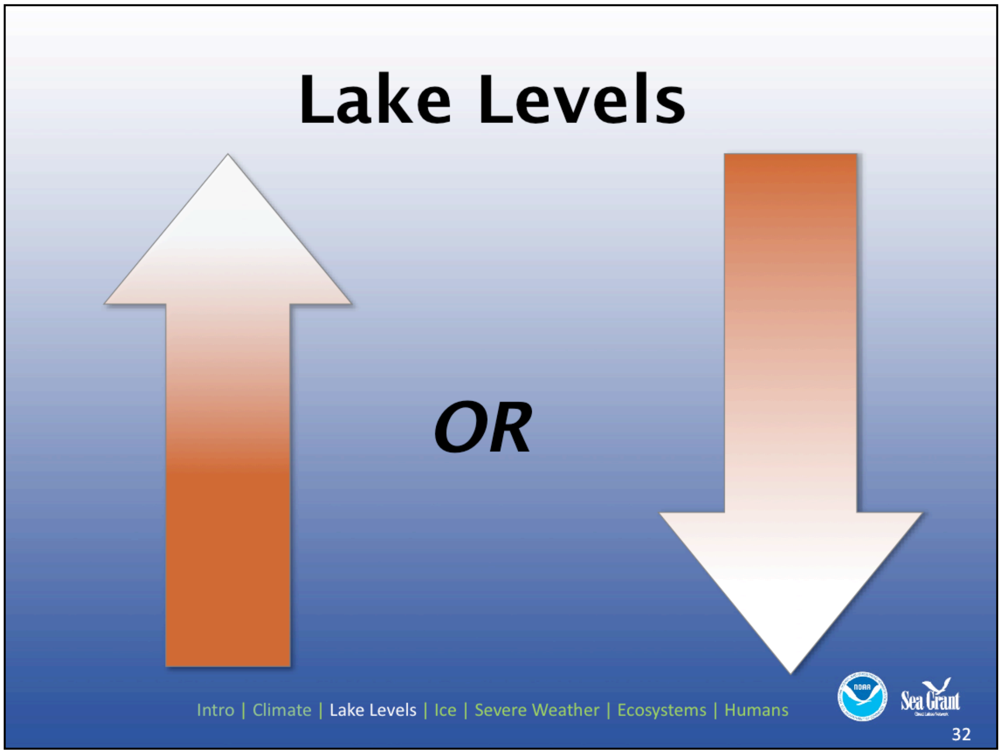


Now we're going to discuss, in more detail, the observed and projected impacts of climate change in the Great Lakes region.



For today's presentation potential climate change impacts have been broken into 6 somewhat interrelated categories all centered around the principle that climate change will have consequences for the earth's system and human lives.

Let's start with Lake Levels.



So, one question scientists are trying to answer is whether will the water level in the Great Lakes will go up or down?

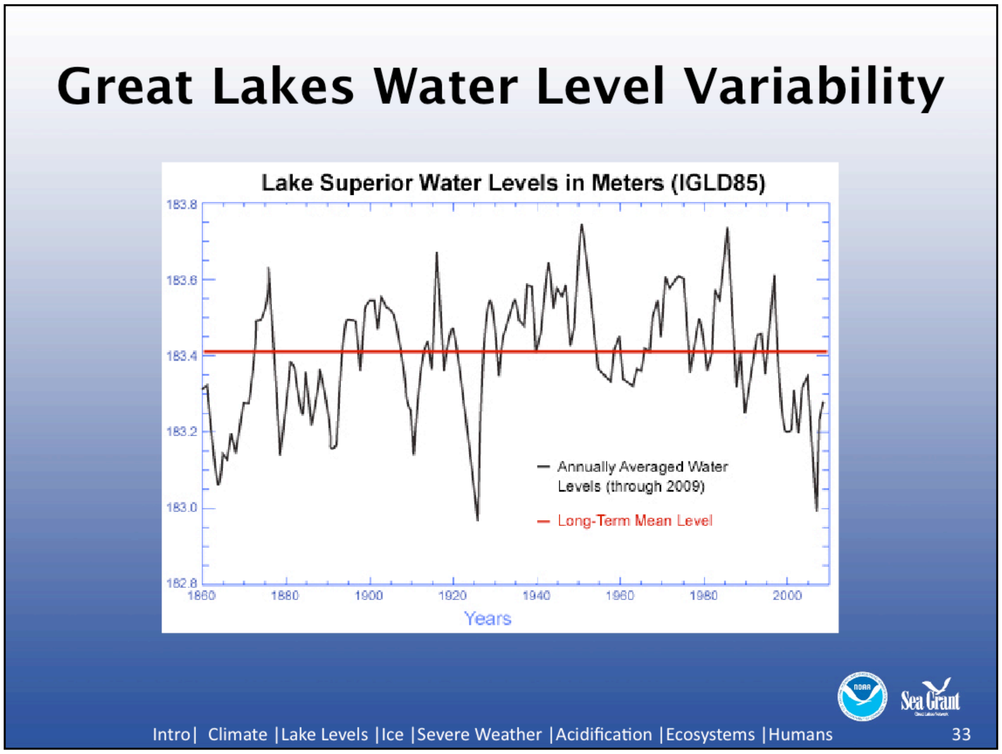
There is still uncertainty about how exactly climate change will affect the levels of the Great Lakes. There is a range of predicted changes in lake levels over the next 50-100 years, with Scientists previously finding an overall downward trend in lake levels to be expected. More recent research suggests lake levels may actually increase. Regardless, what we do know is that lake levels will continue to experience variability- as they have been observed to do over the last 150 years. With climate change, that variability is likely to become more extreme.

Source:

"Global Change Impacts in the United States, Midwest Report", *United States Global Change Research Program*: http://www.globalchange.gov/images/cir/pdf/midwest.pdf

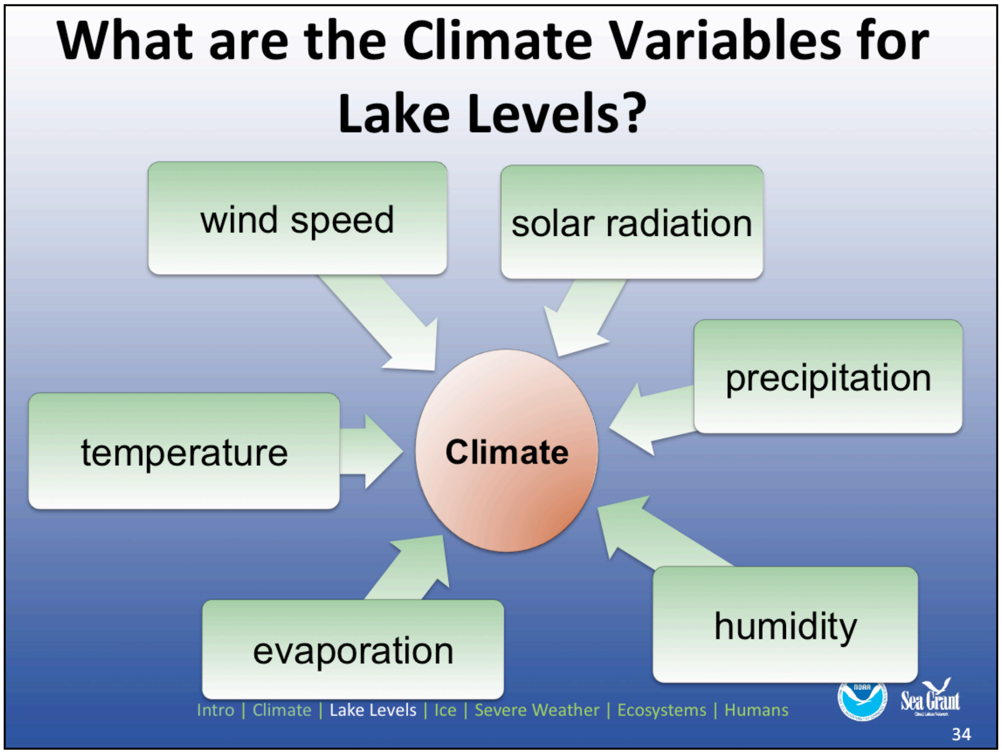
Notes:

"The pendulum of research is swinging away from the previous perceived level of certainty of drops in lake levels. Research that has not yet passed peer review is showing the potential for rises in lake levels and giving a harsh critique of the methods that were previously used to predict dropping lake levels. However, here is what has been peer-reviewed: Manabe et al. (2004) and Milly et al. (2005) both give projections of increased outflow from the St. Lawrence River based on global models, while Kutzbach et al. (2005) projects increased water vapor flux convergence over the Great Lakes basin, again based on global models. All of these necessarily imply rises in lake levels, but because they don't explicitly state and quantify this, they have not been given due attention from those who do studies of impacts and from the media." Brent Lofgren, NOAA GLER; November, 2010.



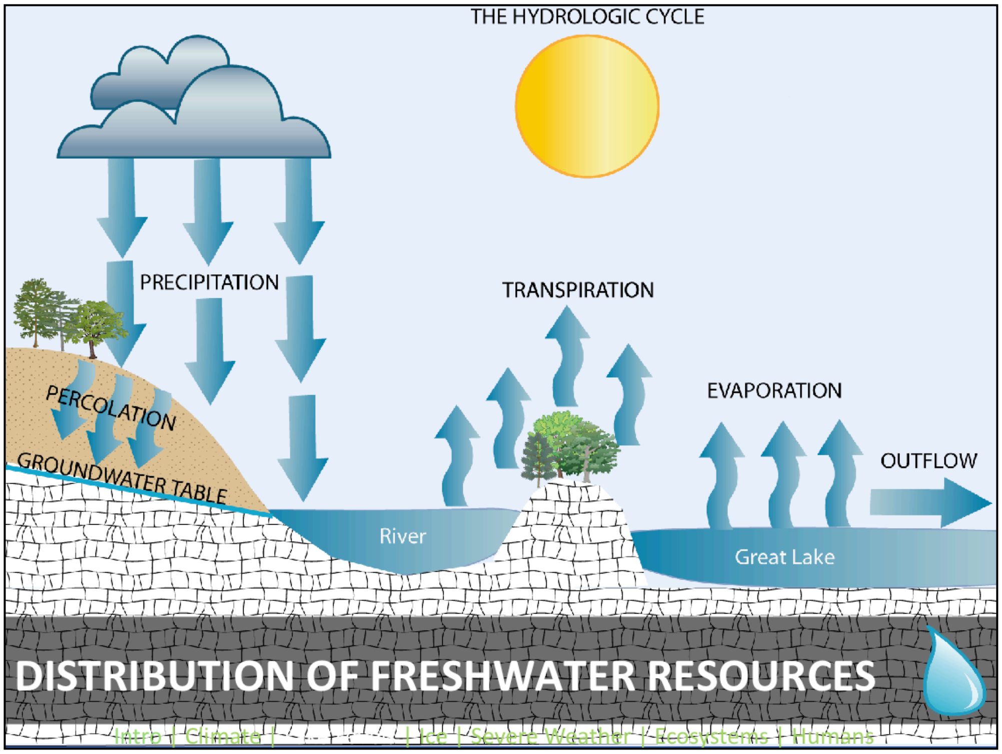
In fact, lake levels are already in a constant state of flux; Great Lakes water levels have varied considerably even over the past several hundred years. As shown on this graph, over the last 150 years, Lake Superior has fluctuated about 2.5 feet (0.8 m). The high water level in October of 1985 was 3.9 feet (1.19 m) above a low in March of 1926.

The data in this graph originated from the U.S. Army Corps of Engineers-Detroit District.



This natural variation in lake levels is influenced by many environmental factors. Those environmental factors include:

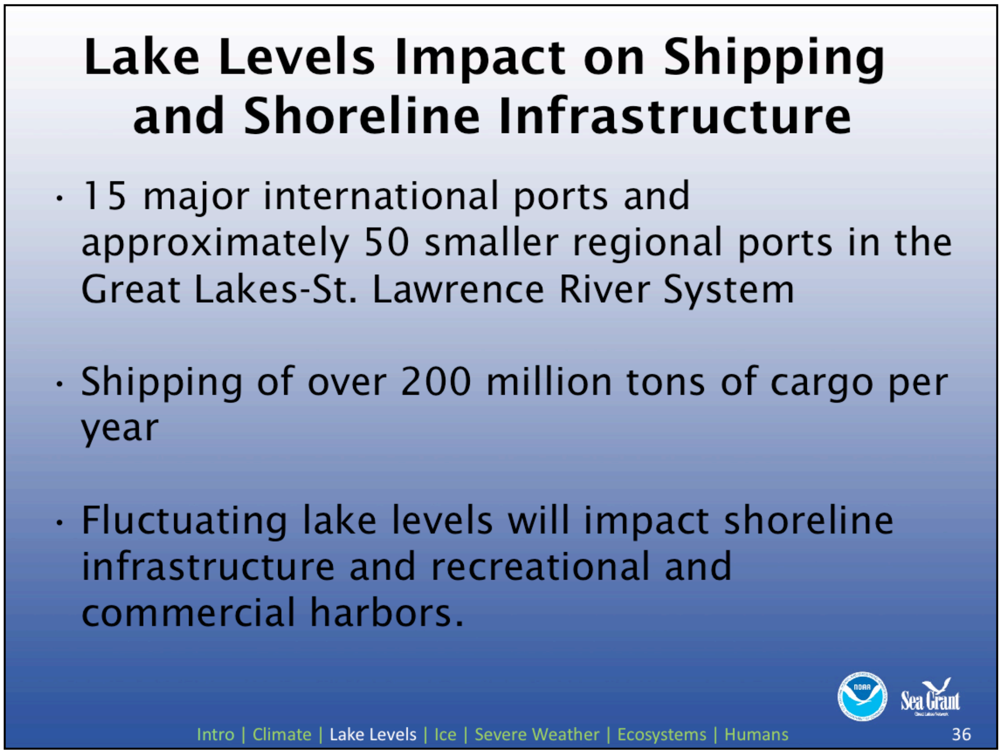
Solar Radiation, Precipitation, Humidity, Evaporation, Temperature, and Wind Speed. As climate change affects the relative strength and intensity of these environmental factors, natural lake level variation will likely become even more pronounced.



To understand how lake levels may vary, let's take a look at how those environmental factors influence the hydrologic cycle. Precipitation falls as rain or snow and collects as groundwater and in rivers and lakes. Plants give off moisture back into the atmosphere through transpiration, and moisture also returns to the atmosphere through evaporation from water bodies. Warmer temperatures in the summer, combined with less ice cover in the winter, will result in greater evaporation. As more water leaves the lakes and enters the atmosphere, there is the potential for water levels to drop, if all else is held constant in the environment.

Based on most peer-reviewed studies scientists currently believe that lake levels will fall over the next century – although there will continue be a great deal of year-to year fluctuation or variability.

Source: "Global Change Impacts in the United States, Midwest Report", *United States Global Change Research Program*: http://www.globalchange.gov/images/cir/pdf/midwest.pdf



Changes in lake levels will have an impact on the region's shipping industry. Shipping is an important component of the Great Lakes region's economy: there are 15 major international ports and approximately 50 smaller regional ports in the Great Lakes-St. Lawrence River System shipping over 200 million tons of cargo per year. As we noted, there is a range of predicted changes in lake levels over the next 50-100 years, with an overall downward trend in lake levels expected—but that trend will be marked by significant variability and fluctuations. These fluctuations may affect shoreline infrastructure, requiring increased dredging of channels for port access. Recreational and commercial harbors will also be impacted by shifting lake levels.

Looking at how the salty coast deals with shifting water levels due to tidal influences could be a way for Great Lakes communities to make their shoreline infrastructure more adaptive to varying lake levels.

Sources:

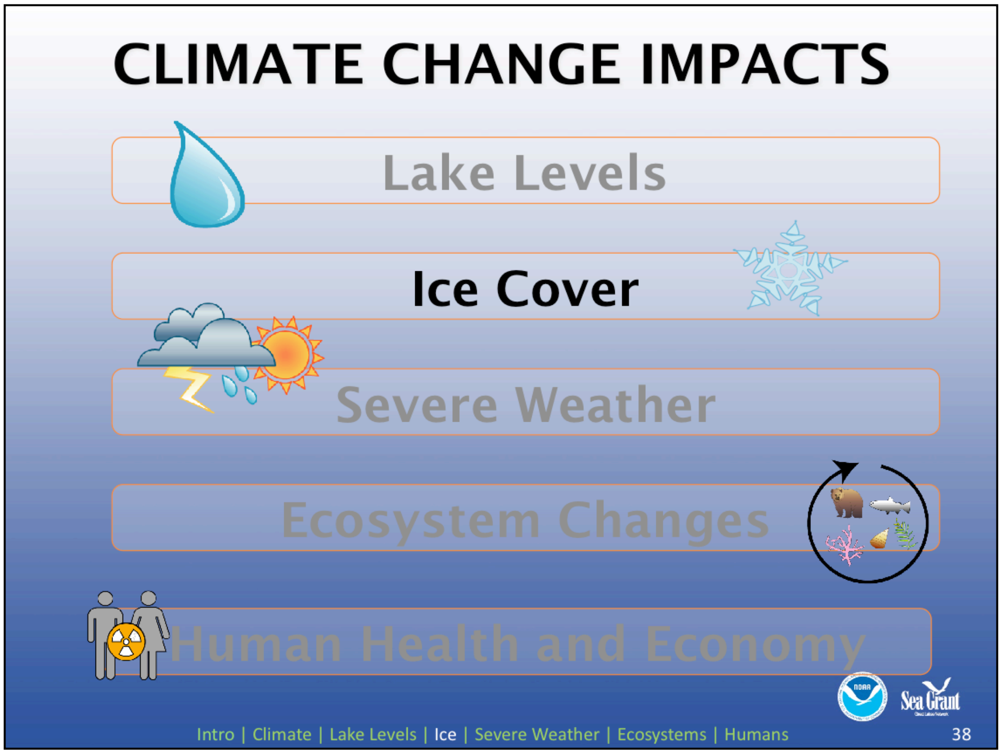
Great Lakes Needs Assessment Ports and Navigation. Final Draft Interim Report August 18, 2006. Great Lakes Commission and NOAA/ Coastal Services Center.
Available at: <http://www.glc.org/regionalneeds/>

Savonis, Michael J., Burkett, Virginia R., and Joanne R. Potter. (coordinating authors) March 2008. "Impacts of Climate Change and Variability on Transportation Systems and
Infrastructure: Gulf Coast Study, Phase I." U.S. Climate Change Science Program Synthesis and Assessment Product 4.7: Report by the U.S. Climate Change Science
Program and the Subcommittee on Global Change Research

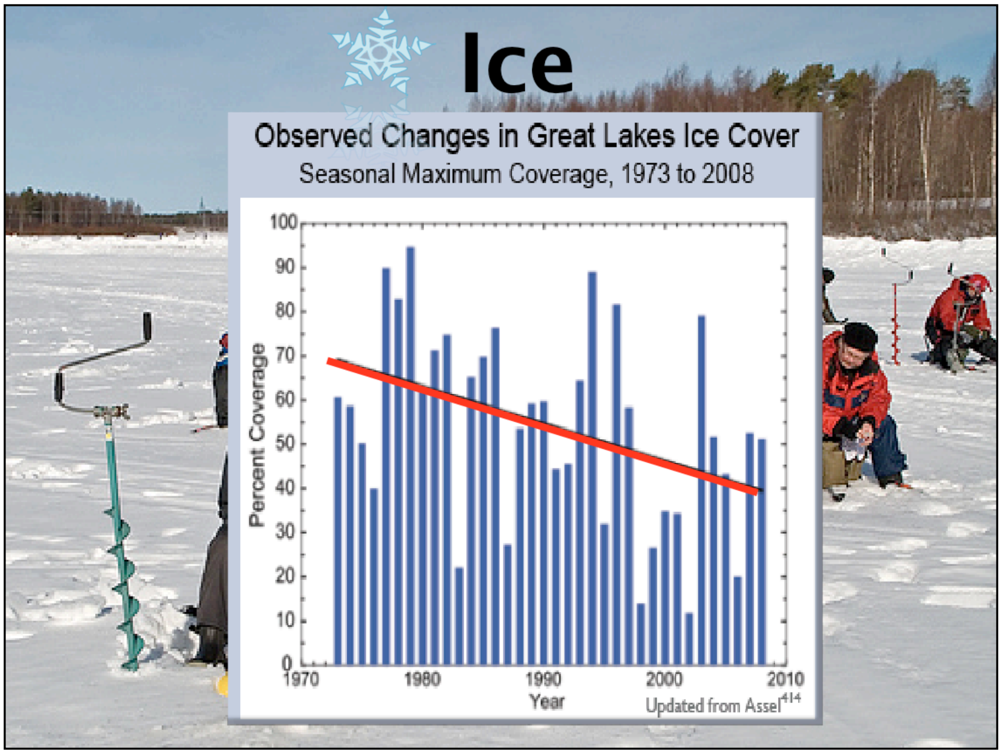
Transportation Research Board Special Report 290. 2008. "The Potential Impact of Climate Change on U.S. Transportation." Transportation Research Board: Washington, DC

Lake Levels Summary

- Range of predicted lake levels but with a likely overall downward trend
- The Great Lakes have already seen natural variation in lake levels; this variation will continue and be amplified by climate change
- Various environmental factors impact levels, such as solar radiation, precipitation, humidity, evaporation, temperature, and wind speed
- Shifting lake levels will impact shoreline infrastructure and shipping



Now lets talk about how climate change will impact ice cover on the Great Lakes.



The predicted impact of rising temperatures in the Great Lakes is a reduction in seasonal ice cover. While this graph of Great Lakes ice cover indicates large year-to-year variations, there is a clear decrease in the extent of Great Lakes ice cover as shown by the red line.

So to recap, we've talked about lake level changes, projected temperature increases, and a reduction in ice coverage on the lakes.

Source: "Global Change Impacts in the United States, Midwest Report", *United States Global Change Research Program*: http://www.globalchange.gov/images/cir/pdf/midwest.pdf

Notes Related to snow cover:

Isard et al. (2007) found that one impact of ice cover change is the reduction in soil temperatures. The authors suggest that the decrease is due to less snow cover, which insulates the ground from the frigid winter temperatures. Snow cover in the northern hemisphere has declined by 5% since 1975. If this trend continues, the decrease in soil temperatures will impact a variety of plants and animals in the region. Lower soil temperature might also impact growing seasons.

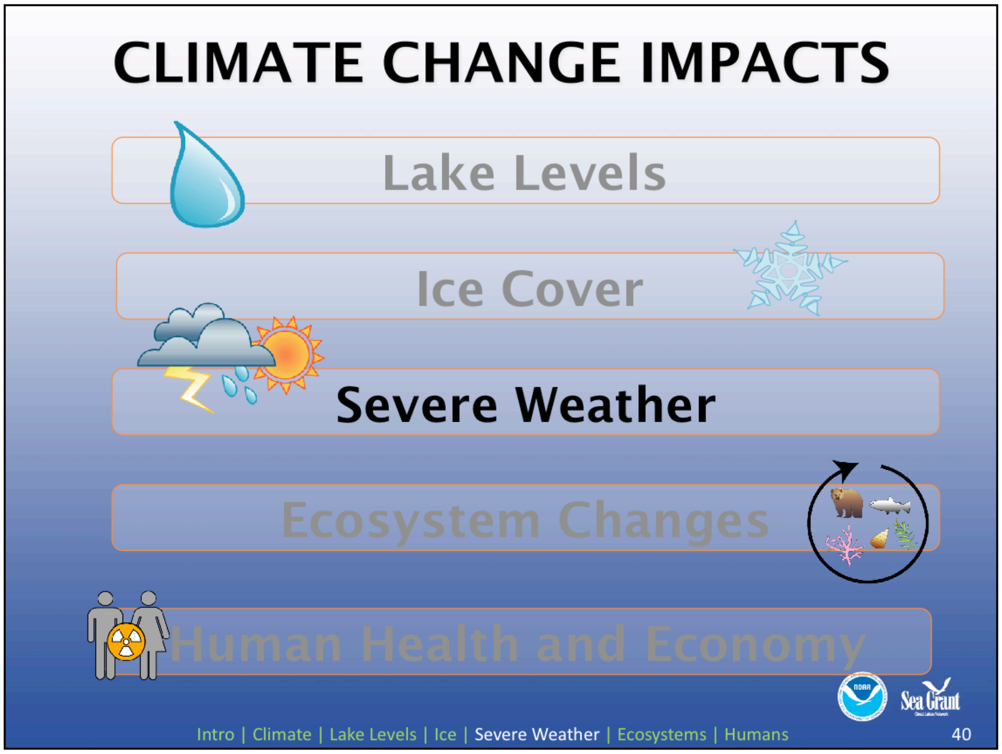
Image Sources:

http://www.flickr.com/photos/henribonell/3376075968/sizes/m/

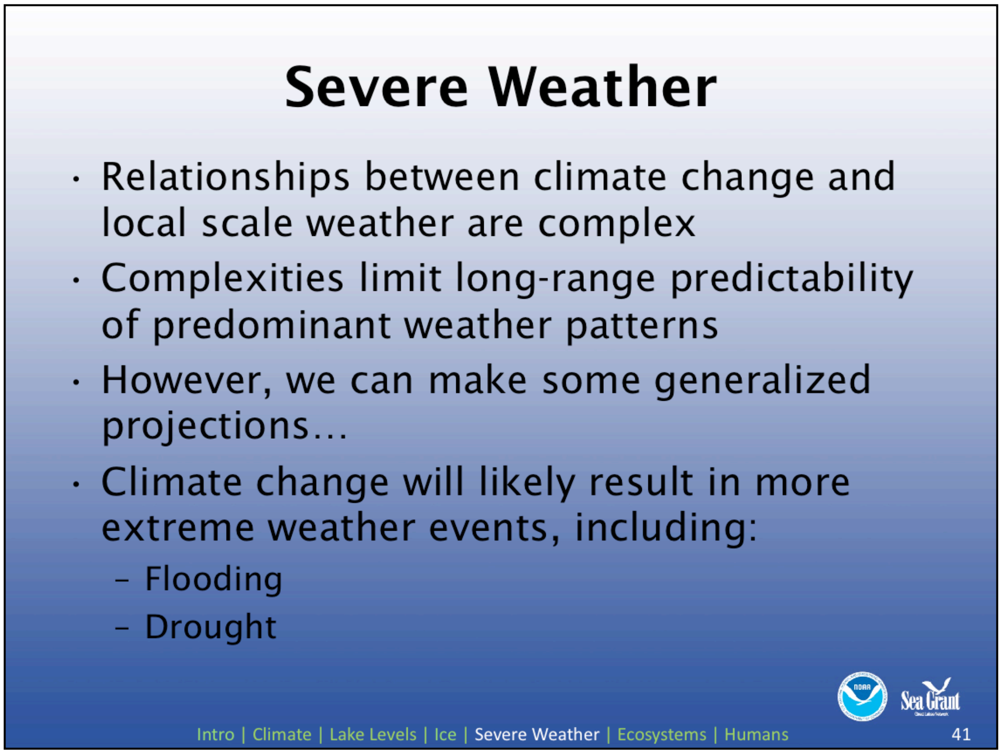
http://www.flickr.com/photos/javatopia1/106474947/

Source:

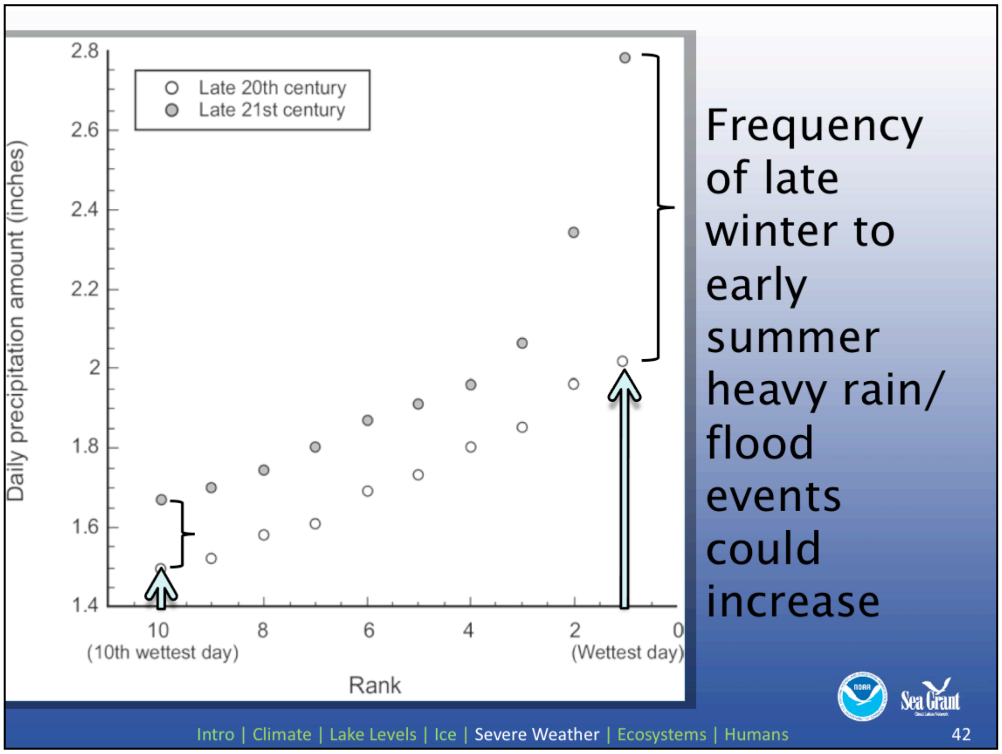
Isard, S. A., R. J. Schaetzl, et al. (2007). "Soils cool as climate warms in the Great Lakes Region: 1951-2000." Annals of the Association of American Geographers 97(3): 467-476.



Now let's discuss how climate change may change severe weather patterns in the Great Lakes region.



While climate change is unequivocal and always occurring, the relationship between climate change and local weather is complex. These complexities limit the long-range predictability of predominant weather patterns. We can, however, make some general predictions about how climate change will impact weather…for example, climate change is expected to result in more extreme weather events, such as flooding and drought.

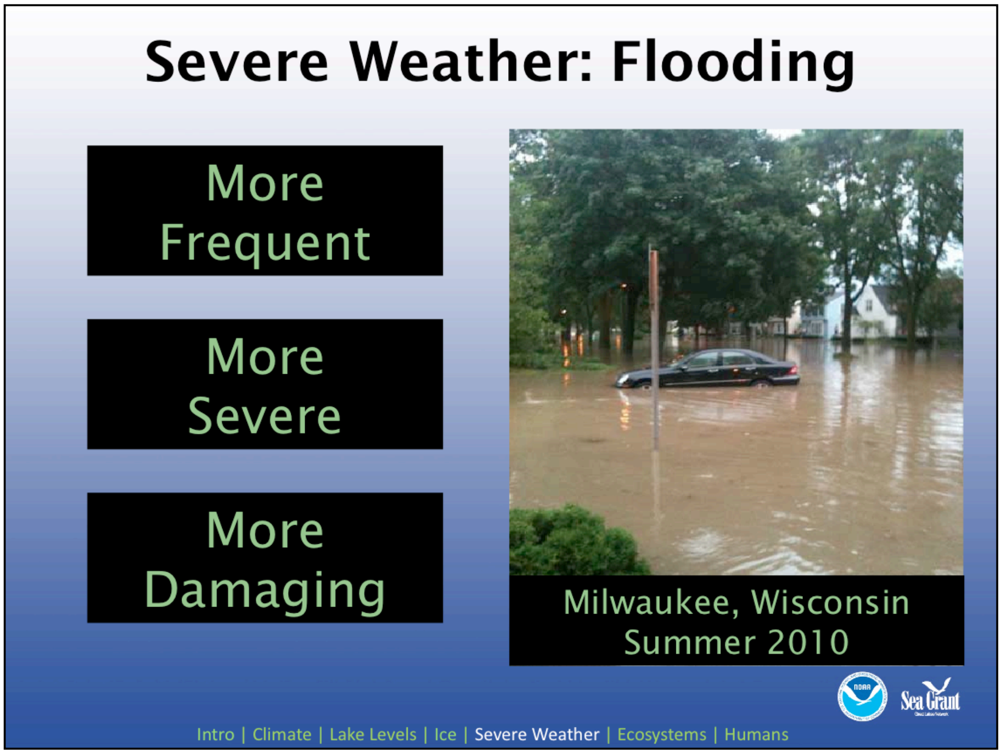


More extreme weather events means the frequency of late winter to early summer heavy rain & flood events will likely increase…due to increases in atmospheric heat and moisture capacity over the region. One recent study on future weather patterns in Southern Wisconsin concluded that Southern Wisconsin will see a 10-40% increase in the intensity of heavy rain events by the end of the 21st century. This graphic is part of that study… let me explain. This graph depicts the 10 wettest days of the year in Southern Wisconsin…both in the late 20th century…plotted as open circles… and in the late 21st century… plotted as the grey, filled in circles. The bottom axis shows the 10 wettest days of the year…while the left axis shows the theoretical daily precipitation amounts.

[CLICK…arrow appears on 10th wettest day] Note that on the 10th Wettest day of the year rainfall amounts may increase from around 1.5 inches to about 1.7 inches. **[CLICK…arrow appears on wettest day]** Now look at the wettest day of the year. At the end of the 20th century we might expect about 2 inches of rainfall… while at the end of the 21st century that amount would increased to greater than 2 ¾" of rainfall.

Source:

Patz, Jonathan A., Stephen J. Vavrus, Christopher K. Uejio, Sandra L. McLellan. 2008. Climate Change and Waterborne Disease Risk in the Great Lakes Region of the U.S. American Journal of Preventative Medicine 35 (5): 451-458.



In the United States, extreme weather events—high amounts of precipitation within a short period of time—have made up a disproportionate share of the observed increases in total precipitation. For example, the number of days with precipitation greater than two inches has increased. Increases in precipitation accumulations has been the greatest in the Great Lakes and Southwest and Midwest regions of the United States. One recent example of flooding in the Great Lakes region was in July 2010 in Milwaukee, WI, when over 6 inches of rain fell in 1 hour …and more than 9 inches in 12 hours. This resulted in around 2 billion gallons of combined sewer overflows (a mix of rainwater and raw sewage).

Extreme precipitation creates risks for flooding and erosion, water quality deterioration (due to entrainment of pollutants and sewer overflow) and human health concerns (such as more frequent outbreaks of water-borne diseases, especially in rural areas). More extreme precipitation events will also require more resources from local and state governments to deal with flood clean-up, increased maintenance costs, and increased water treatment costs.

Sources:

Karl, T.R., R.W. Knight, D.R. Easterling and R.G. Quayle. 1996. "Indices of climate change for the United States." Bulletin of the American Meteorological Association 77 (2): 279-292.

IJC, 2003. "Climate Change and Water Quality in the Great Lakes Basin."

One example of a community dealing with extreme weather is Milwaukee, Wisconsin.

Milwaukee works with the Southeastern Wisconsin Watershed Trust to promote green infrastructure to help with more intense rain events.

The partnership uses a comprehensive watershed management approach that helps address cross-jurisdictional issues (between sewer districts, municipalities, and the Southeastern Wisconsin Regional Planning Commission).

Projects include a land acquisition program, promoting downspout disconnection, and installing rain gardens.

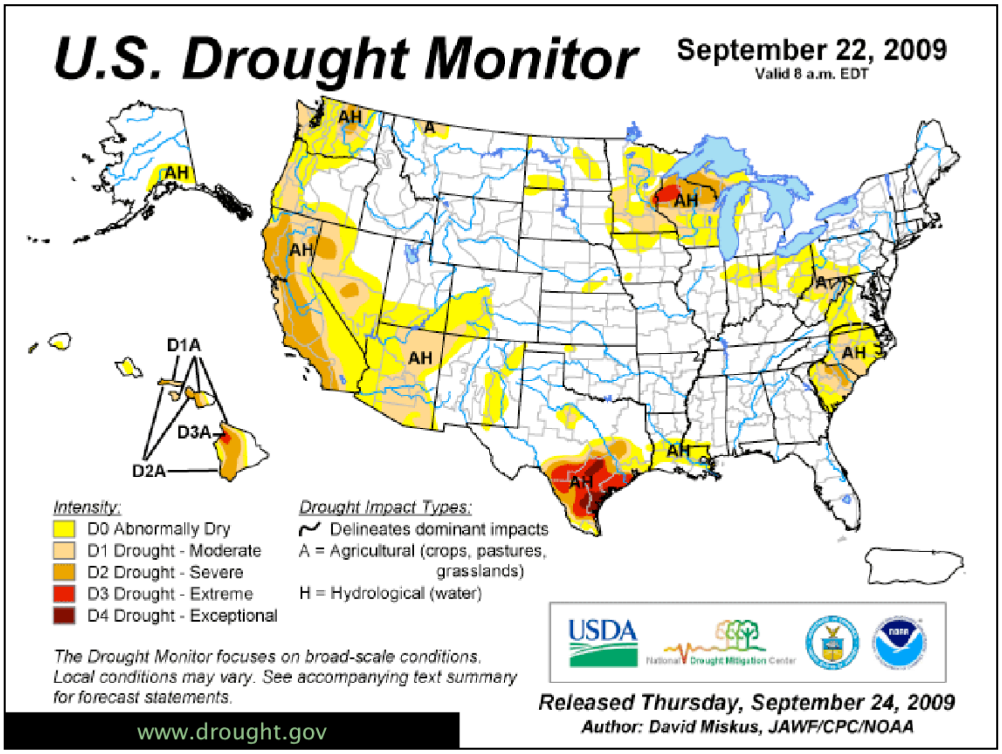
Module 2 will provide more detail about adaptation strategies for dealing with climate impacts, but we wanted to give you an idea of different ways that communities are responding.

Sources:

"Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions", Center for Clean Air Policy, p.19. See Module 2 References.

NOAA Adaptation Guide, p.51 http://v3.mmsd.com/

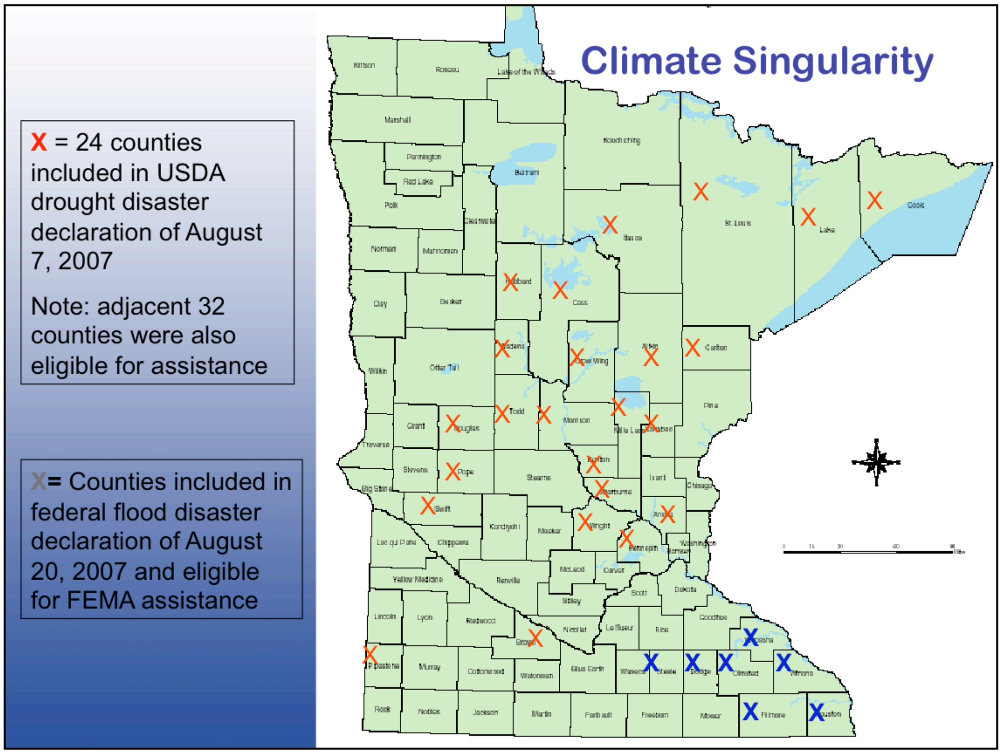
Picture source: http://www.sleepycreekwatershedassociation.org/Content/StormWaterMgmt/rain_gardens.htm



Paradoxically, the Great Lakes may also experience increased drought due to warmer temperatures and increased evaporation between rain events. As temperatures increase…the loss of soil moisture between rain events due to evaporation could more than offset projected increases in rainfall and flood events. The graphic above shows the severe drought occurring over the upper Great Lakes last fall.

For more information on drought… go to www.drought.gov

Source:
www.drought.gov



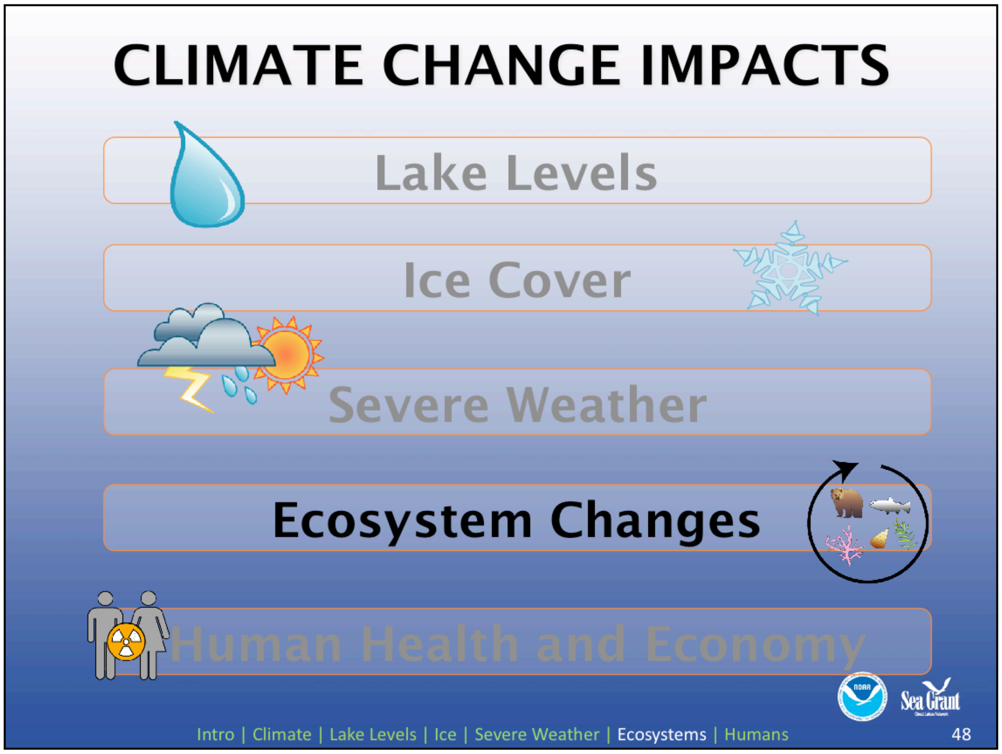
The Great Lakes region is already experiencing extreme weather events which demonstrates the increased variability we will experience from climate change. For example, in August 2007, several counties in the state of Minnesota experienced drought conditions…while at the same time, other neighboring counties experienced flooding. Drought and flood conditions happening at the same time in the same region point to the need for states to develop response plans for a variety of extreme weather events that occur simultaneously.

Source: Mark Seeley, University of Minnesota Extension Climatologist.

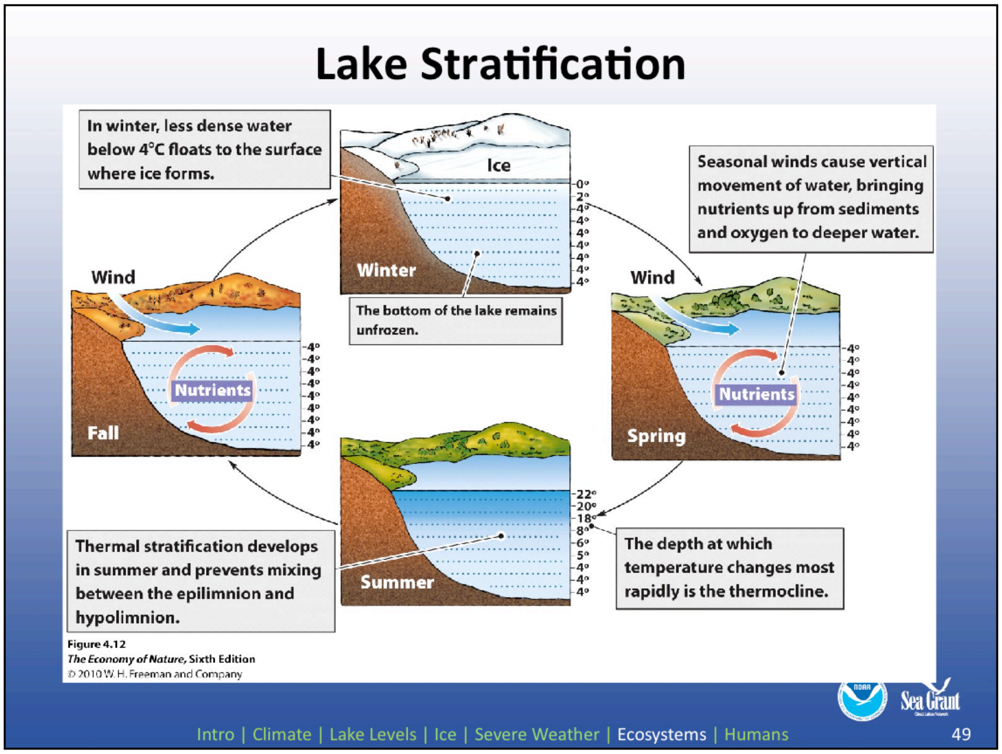
Severe Weather Summary

- Likely increase of heavy precipitation events
  - More severe
  - More frequent
  - More damaging

- Likely increase of drought due to warmer temperatures between rain events



Now that we've talked about impacts on severe weather events, lets consider some ways that the Great Lakes ecosystem might be affected by climate change.



So how will climate change affect Lake ecosystems? In order to understand how these changes would be possible, let's first review how temperature and wind contribute to the seasonal differences we observe in the Great Lakes themselves, by reviewing the process of lake stratification.

Climate change will affect stratification of the lakes, impacting lake ecosystems. Stratification refers to a change in the water temperature at different depths in the lake, and is due to the change in the density (or weight) of water with temperature. Water has the interesting characteristic of its maximum density being at 4°C. Water colder than 4°C is therefore less dense, causing it to float to the surface where ice forms. As water warms in the spring, the ice melts and winds cause water to mix, bringing nutrients up from sediments at the bottom and oxygen down to deeper water—this is called the spring turnover. In the summer, the temperature difference between warmer surface waters and cooler deeper waters is great enough to prevent the mixing of those waters due to differences in density—called summer stratification. In the fall, surface water cools again to a point where the the water has the same density at all depths, enabling it to mix again. In the winter, ice forms a barrier on top of the water, preventing mixing from occurring.

In the Great Lakes Region where water warms and cools through the seasons, a cyclical pattern of overturn occurs, affecting the biogeochemistry and ecology of the lake.

This process will be affected by climate change, with the spring turnover occurring earlier in the year and the fall turnover occurring later. Winter stratification will also be affected if ice does not form due to warmer temperatures; with no ice to act as a wind barrier, lake turnover would happen continuously from fall until spring.

For example, Lake Superior's spring turnover has become earlier by about ½ day per year, leading to earlier summer stratification. The sun-warmed upper layer extends farther into the water column, resulting in a later fall mixing. The length of the stratified season has increased from 145 to 170 days over the last century.

Sources

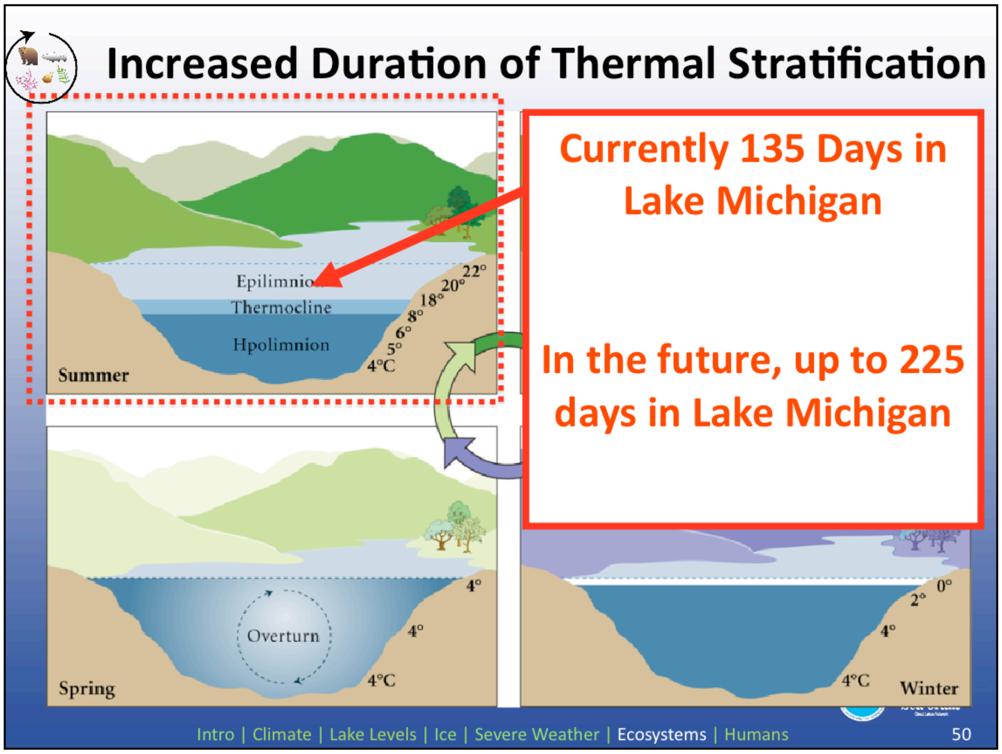
Ricklefs, R. E. 2008. The Economy of Nature, 6th Edition. W. H. Freeman and Co.;

Minnesota Sea Grant: Climate Change and Lake Superior. http://www.seagrant.umn.edu/climate/superior.

Info for that website taken from:

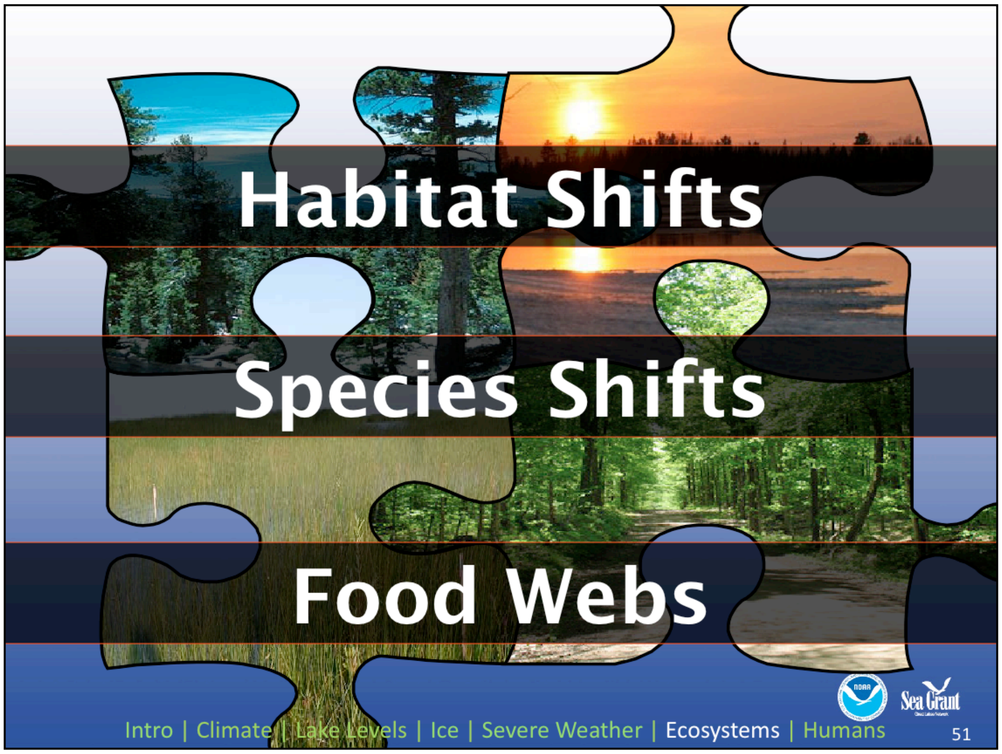
Austin, J.A. and S.M. Colman. 2007. Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback, *Geophys. Res. Lett., 34, L06604, doi: 10.1029/2006GL029021. www.agu.org/pubs/crossref/2007/2006GL029021.shtml;* and

Austin, J.A. and S.M. Colman. 2008. A century of temperature variability in Lake Superior. *Limnol. Oceanogr. 53, 2724–2730. www.aslo.org/lo/pdf/vol_53/issue_6/2724.pdf*



Today thermal stratification lasts about 135 days. Under some climate change scenarios the period of thermal stratification could reach 225 days by the end of the century!! By lengthening the period of low-oxygen and low-nutrient water at the surface, fish and other animals will be stressed, and fish kills may be more prevalent.

Source: Angel and Kunkel (2009)



In addition to the Lakes themselves, the Great Lakes region includes numerous other ecosystems and habitats such as coastal wetlands, northern hardwood and coniferous forests, and beaches and dunes. Many of these habitats have been stressed or altered by weather and human activities over time.

On top of the changes humans bring to the ecosystem, relatively small changes in temperature or water levels can have a cascading impact through the system as habitats become drier and species shift to remain in their preferred temperature range. These shifts can alter the relationships between species and how they use their habitats.

Images:
http://www.marietta.edu/~biol/biomes/images/alpine/cforestmt.jpg
http://www.thedailygreen.com/cm/thedailygreen/images/7Z/sunset-hoyt-lake-032309-lg.jpg
http://www.uwgb.edu/biodiversity/econotes/2003/bradwetland2.jpg
http://www.northernlakesrealestate.com/i/p-cf0713-b.jpg

One of the major impacts of rising temperatures in the Great Lakes region will be shifts and expansion of species to the north. Numerous studies are documenting movements by species as they seek out the best conditions for their survival.

Small mouth bass are an example of a warm-water fish that may see its habitat range expand. One study estimated an expansion all the way into northern Canada by the end of the century. This is great for sport fishermen who like to catch small mouth bass, but maybe not so great for those who like to catch lake trout and whitefish, since those species will decline if cold water areas shrink dramatically.

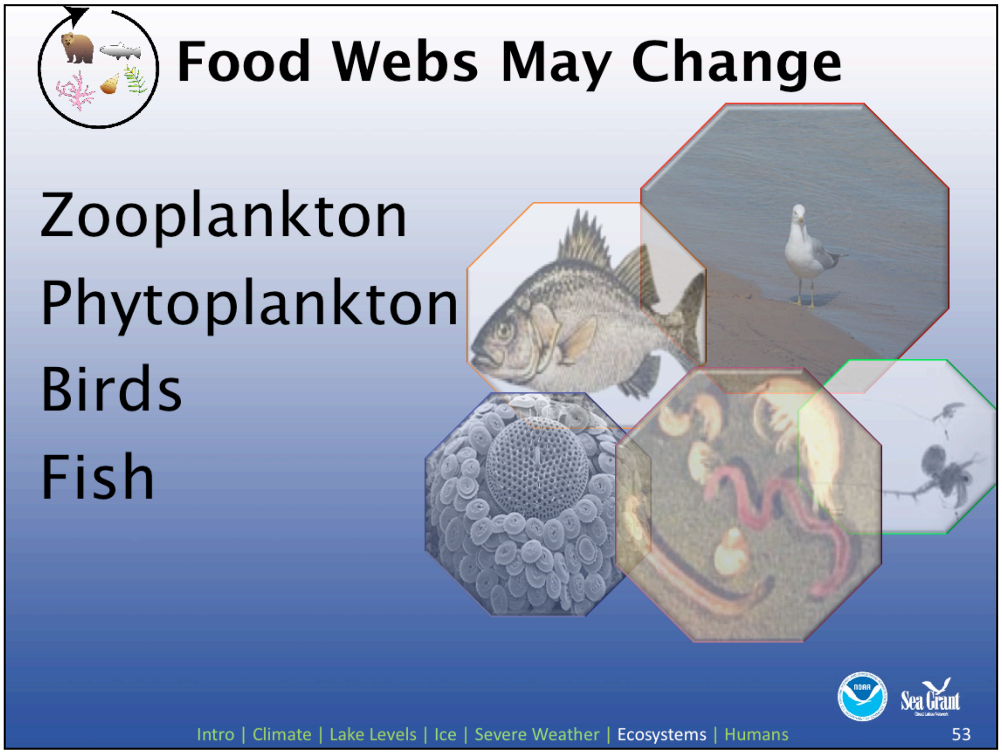
A recent study tracking small mammals in Michigan found that flying squirrels' range has shifted north. The flying squirrel population is increasing in the upper peninsula, while their brethren below the bridge are having trouble.

Native tree species are expected to move north as they are replaced by other trees from the south. A study in Ohio, Indiana and Illinois predicted that northern conifers such as eastern hemlock and white pine and deciduous trees such as the Sugar Maple would be completely eliminated in these states, as their optimal growing conditions shift to the northeast.

Researchers conclude that wetland habitats and species will be the most severely affected by climate change since they are sensitive to water levels and hydrology.

Sources:

http://www.ucsusa.org/greatlakes/glregiomic_fis.html



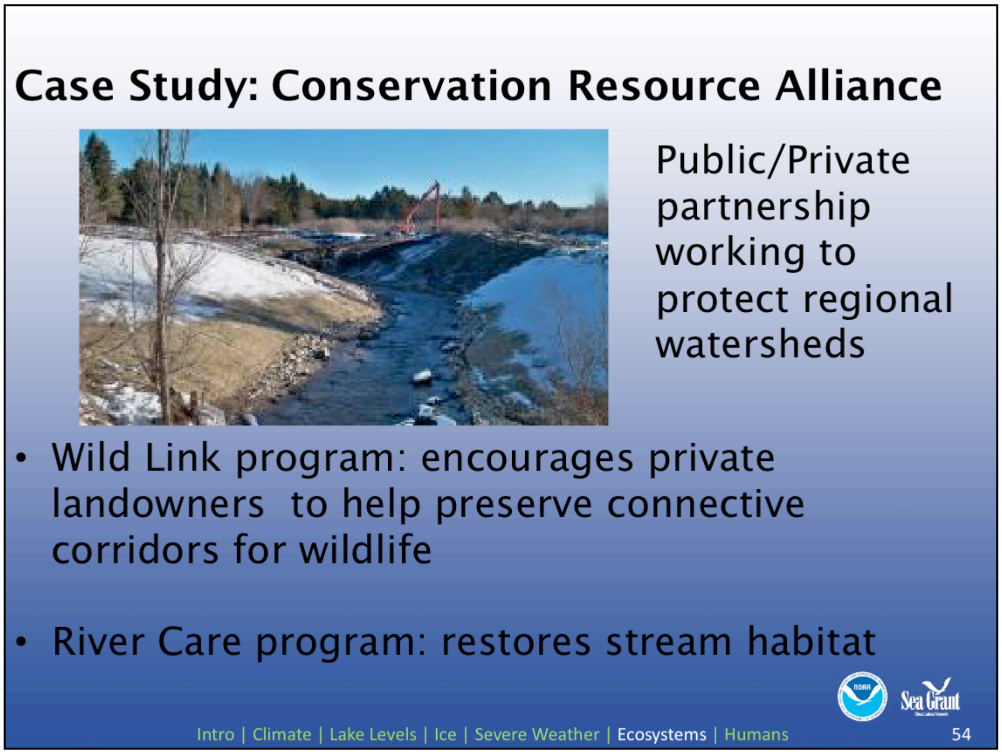
Because of species shifts, habitat changes, and a lengthening of the thermal stratification period, we can expect climate change to disrupt food webs in the Great Lakes. A simplified version of a food web in the Great Lakes includes phytoplankton (drifting microscopic plants), zooplankton (drifting animals such as larval fish and invertebrates), larger fish, and birds.

Changes in availability of phytoplankton at the base of the food web because of nutrient depletion will directly affect animals that consume them, and will indirectly affect animals higher in the food web.

Changes in habitat conditions that affect species distribution can change food webs because not all of the food web components may be equally sensitive to warmer temperatures or lower water levels. Species that shift geographic distribution may need to also shift their diets.

Changes in habitat conditions and disruptions to food webs may also increase the vulnerability of the Great Lakes to invasive species.

Source:
Doka, et al (2006)



An example of a community responding to ecosystem changes is the Conservation Resource Alliance, set in Northwest Lower Michigan.

The Conservation Resource Alliance works to protect regional watersheds. CRA is a grassroots network of local support for on- the-ground conservation action at all levels, from individual landowners and citizens to local, state, and federal governmental agencies and many of the large corporations and foundations in the Great Lakes region and around the country.

CRA has two programs that help address ecosystem challenges: the Wild Link Program supplements public conservation areas by encouraging private landowners to help preserve connective corridors for wildlife. Wild Link is a voluntary program that assists private landowners in managing corridors on their property that wildlife may use to travel from one large parcel of land, such as a state forest, to another.

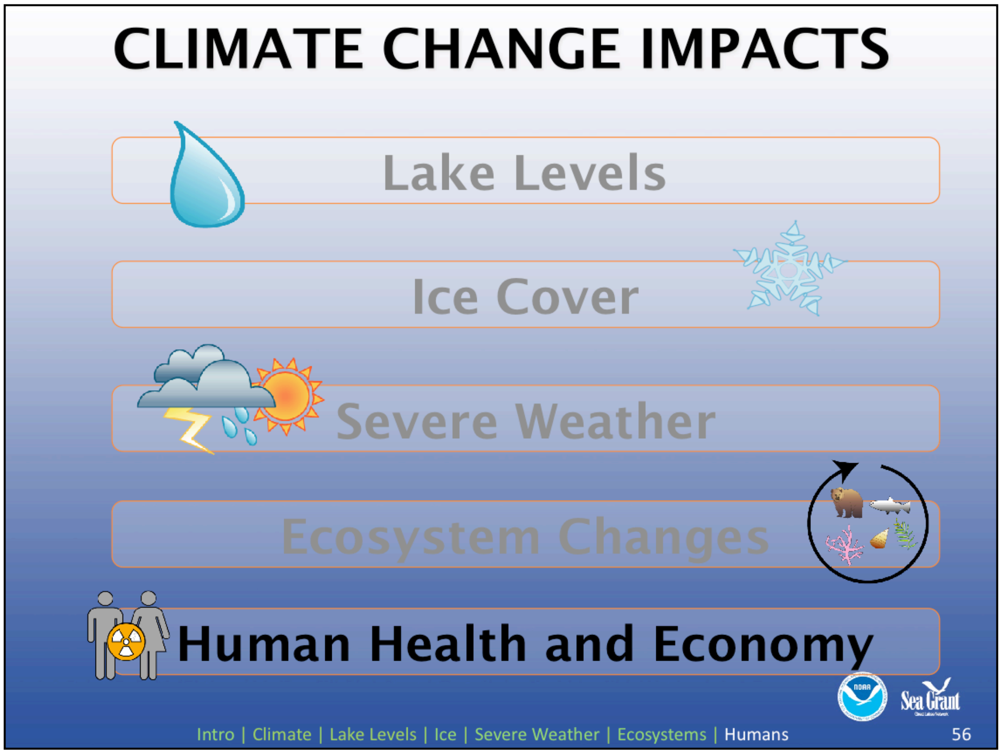
CRA's River Care is a watershed-based program through which CRA leverages financial and in-kind support to perform on-the-ground habitat improvement and restoration projects on a number of world-class trout streams in northwest lower Michigan.

Image above shows removal of the aging Wheeler Creek Dam taking place, allowing Wheeler Creek to freely flow into the Manistee River (courtesy rivercare.org).

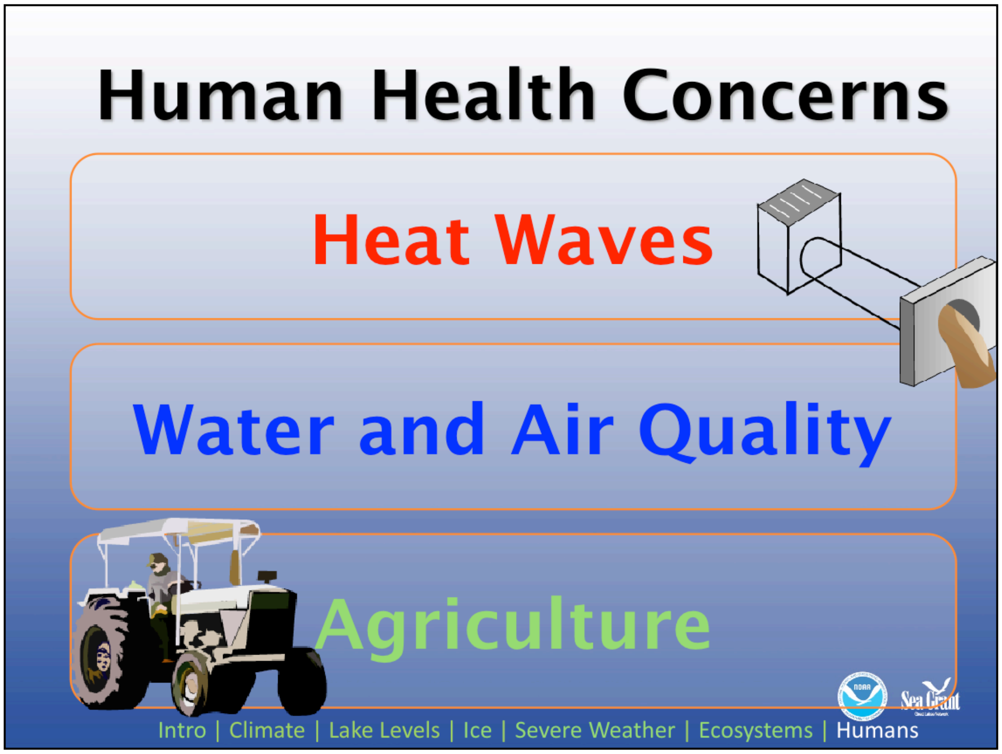
http://www.greeninfrastructure.net/sites/greeninfrastructure.net/files/5-CRA%2008.30.05_0.pdf

Ecosystem Changes Summary

- Changes in lake stratification due to warming temperatures will affect the biogeochemistry and ecology of lakes.
- Plant and animal habitats will shift to the north.
- Food webs may change due to shifting species habitats.



Humans are an integral part of Great Lakes ecosystems. Let’s also talk about how human health and welfare might be affected by climate change.



We're going to talk about three concerns of specific interest in the Great Lakes: the effect of extreme weather on human health, the effect of climate change on water quality and disease, and the effects of climate change on agriculture.

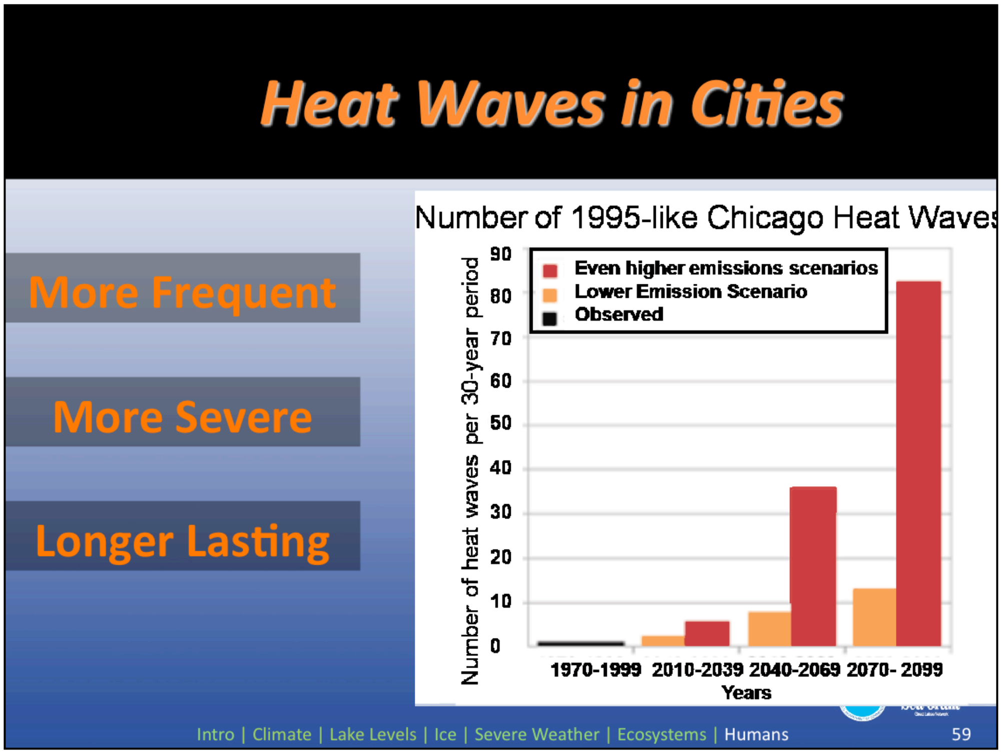
We'll start with the impacts of heat waves on human health. Some of you may not know that the natural hazard that kills far more people than any other is extreme heat. In July 1995 a severe week-long heat wave hit Chicago. [click to bring up photo of woman]

Temperatures peaked at 106 degrees F with a heat index of 126 degrees F. The use of electricity skyrocketed, resulting in power grid failures throughout the city. This was one of the worst weather-related disasters in Illinois history and 525 people died over a 5-day period. [click to bring up red map]

Image Source:

Chicago Tribune, 1995.

Source:
http://www.thedailygreen.com/environmental-news/latest/heat-waves-47121801#ixzz0TkpwKSSU<http://www.thedailygreen.com/environmental-news/latest/heat-waves-47121801>

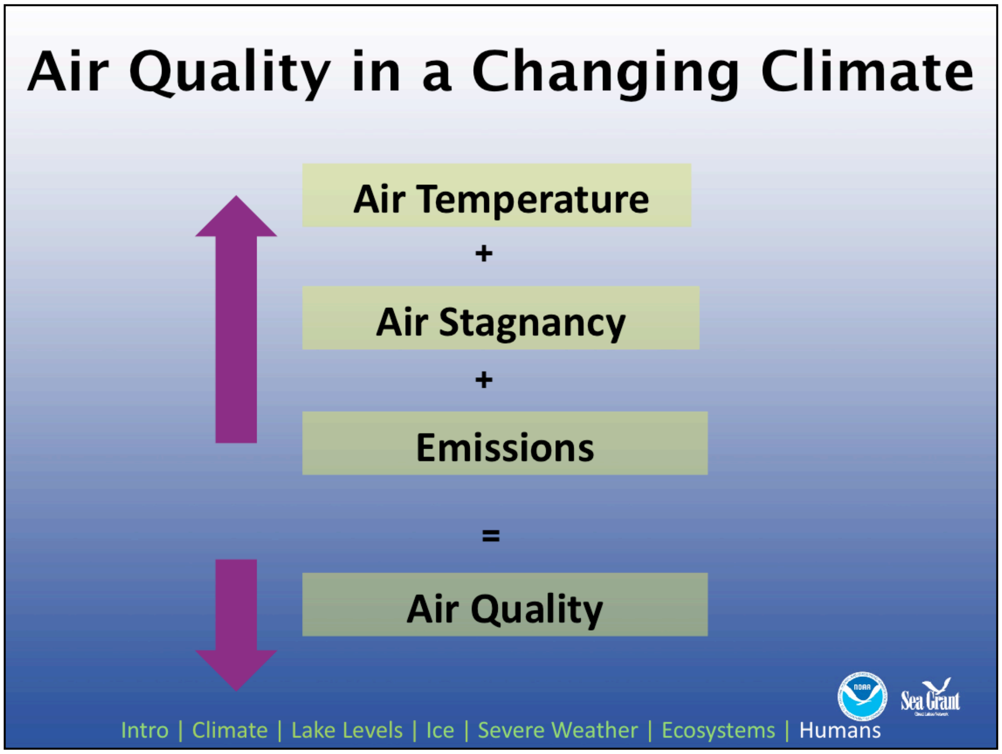


More frequent extreme heat events are expected over the next century as a result of climate change. The Midwest might see extreme heat events every three years by 2080. Note that definitions of “extreme heat” vary from location to location. Extreme Heat in Phoenix is different than “extreme heat” in Quebec. What qualifies as “extreme heat” depends on the local climate in a particular city and what its residents are acclimated to. [click to bring up chart and clear all other pictures/titles]

Considering higher emissions scenarios, and combining temperature increases with the urban heat island effect, we might see as many as 80 deadly severe heat incidents in cities like Milwaukee or Chicago over a 30 year period. [click to reveal summary points]

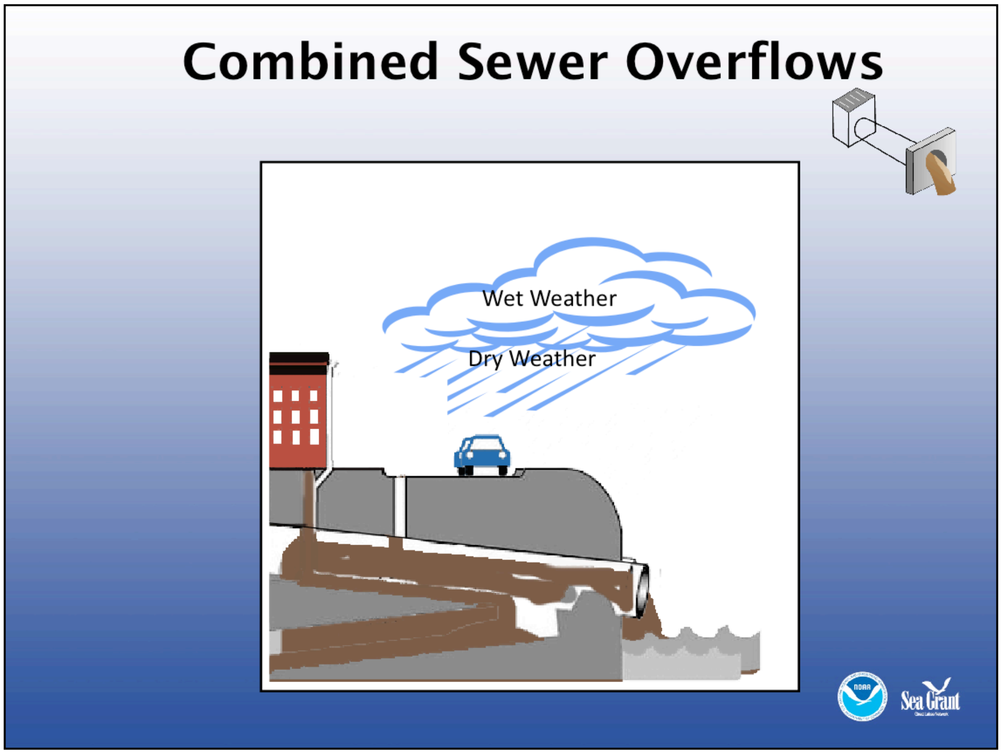
Source:

http://www.thedailygreen.com/environmental-news/latest/heat-waves-47121801#ixzz0TkpwKSSU<http://www.thedailygreen.com/environmental-news/latest/heat-waves-47121801>



Heat can also impact air quality. During heat waves in the Midwest, air pollutants are trapped near the surface, as atmospheric ventilation is reduced. Without strict attention to regional emissions of air pollutants, the undesirable combination of extreme heat and unhealthy air quality is likely to result. Climate change will likely cause an increase in surface ozone over the Midwest, partly driven by decreased ventilation due to warmer temperatures.

Shiliang Wu, Loretta J. Mickley, Eric M. Leibensperger, Daniel J. Jacob, David Rind, and David G. Streets, "Effects of 2000–2050 global change on ozone air quality in the United States," JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 113, D06302, doi: 10.1029/2007JD008917, 2008.)



Climate change is also expected to have an impact on water quality. For example, we've noted that the frequency of heavy rain events will increase with climate change. During storms, combined sewer overflows can cause sewage to flow into lakes. How does this happen?

Combined sewer systems collect runoff, sewage, and industrial water in the same pipe. This was economical when all wastewater was discharged directly to rivers before we had treatment plants in the 19th century. Now, the system can handle the whole load during dry weather and direct it all for treatment.

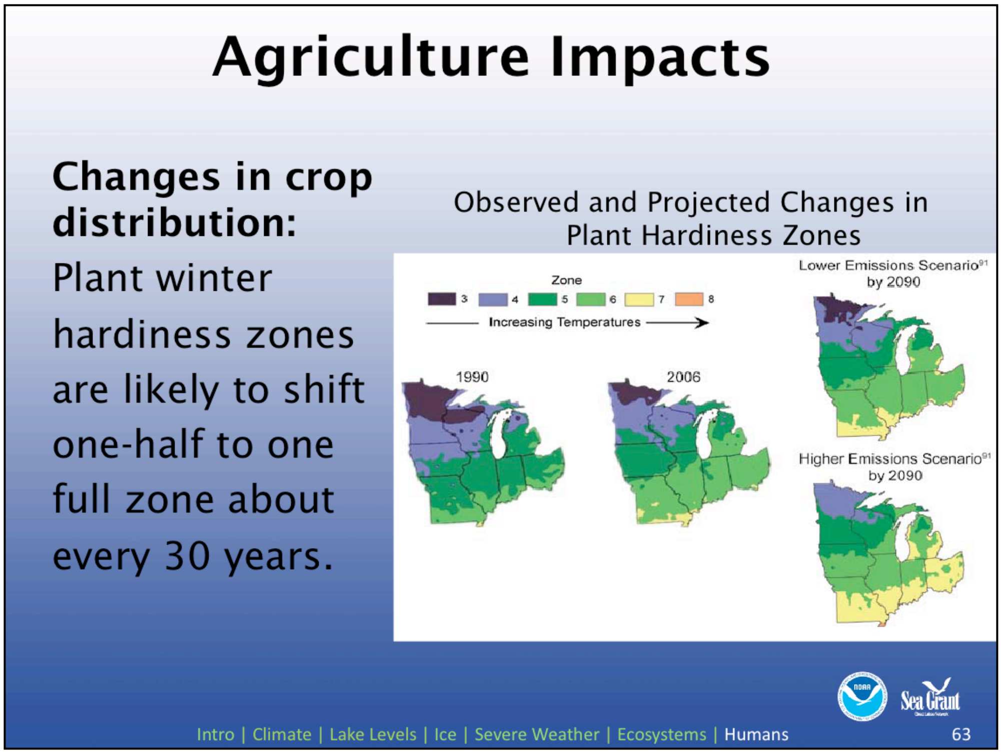
But during big storms, the plants can't handle the volume and the systems are designed to overflow.

When we get over a billion gallons of sewage into our rivers and lakes, water quality diminishes and beaches are closed.

[click] Today, waterborne diseases in drinking water are more prevalent after heavy storm events. For example in 1993, 400,000 people fell ill with diarrhea after an outbreak of a parasitic disease called *Cryptosporidium* which occurred in Milwaukee right after a large storm.

Of the 801 cities in the United States with active combined sewage systems, [click] 65% are in Great Lakes states. NOAA Scientists are improving their capabilities to forecast and warn people of poor water quality after storms.

Source: Patz et al. (2008)



Climate change will also impact agriculture. For the Great Lakes agriculture community, this is good news and bad news. The good news is that with rising temperatures and changes in precipitation, we expect longer and wetter growing seasons.

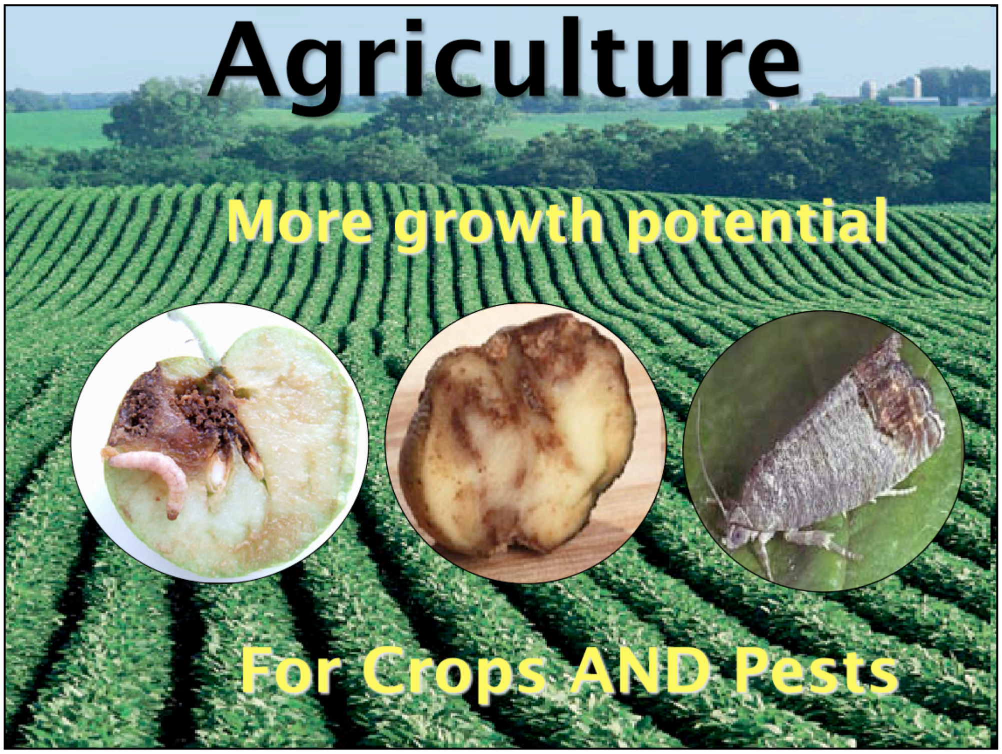
This picture shows how plant hardiness zones are expected to shift as the earth warms. By the end of the century, plants now associated with the Southeast are likely to become established throughout the Midwest.

The bad news…[**click]**

Sources:

Preparing for Climate Change: A Guidebook for Local, Regional and State Governments. http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf

"Global Change Impacts in the United States, Midwest Report", *United States Global Change Research Program*: http://www.globalchange.gov/images/cir/pdf/midwest.pdf



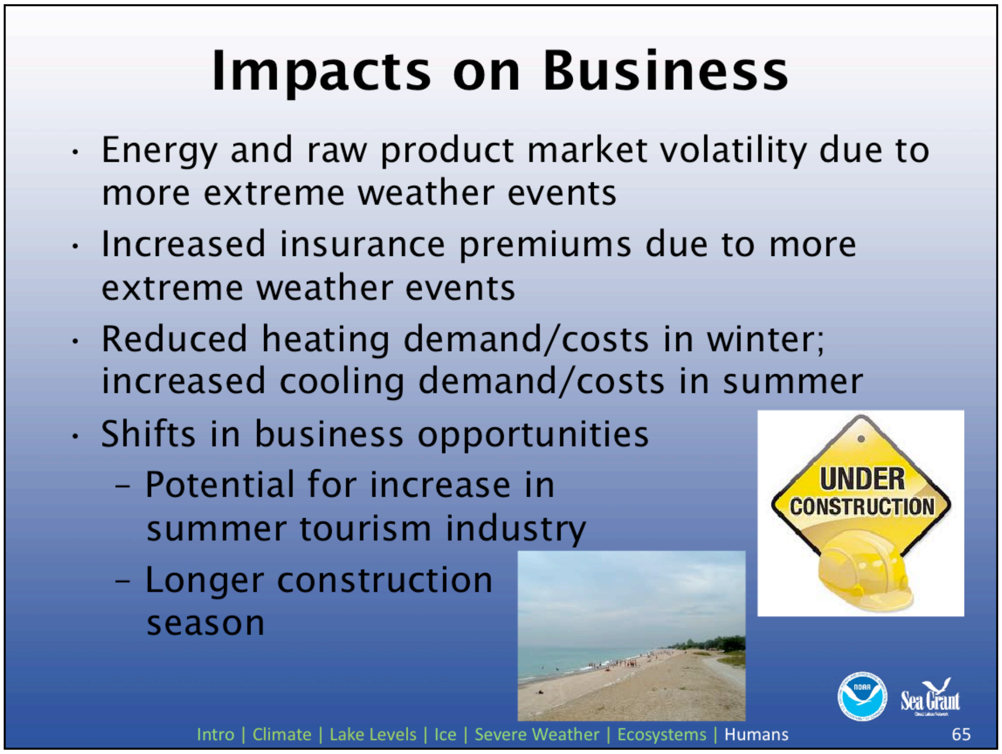
Is that changes in climate are expected to impact crop yields. Several studies report that corn and soybean growing areas will shift north. Another study found that commercial fruit growing conditions will improve near the coasts of the Great Lakes.

It is also anticipated that a longer and warmer growing season will lead to an increased demand for water.

On the flip side, longer growing seasons for crops also provide longer growing seasons for not so economically important organisms, like weeds and pests. [click] Insects that have historically been controlled by cold winters will be more likely to survive milder winters and produce larger populations in a warmer climate.

Longer and warmer growing seasons could contribute to an increased risk of heat stress for crops, as well as an increased demand for water.

We should point out that even though the weather will become warmer and wetter, the soil will still be rocky in the northern Great Lakes region. It remains to be seen whether agribusiness can take advantage of shifts in climate.



Finally, climate change is expected to impact business operations in the Great Lakes region by providing both challenges and opportunities, including:

--Increasing energy and raw product market volatility due to more extreme weather events;

--Increasing insurance premiums due to more extreme weather events;

--Reduced heating demand and lower heating bills in the winter, but increased cooling demand and higher cooling bills in the summer; and

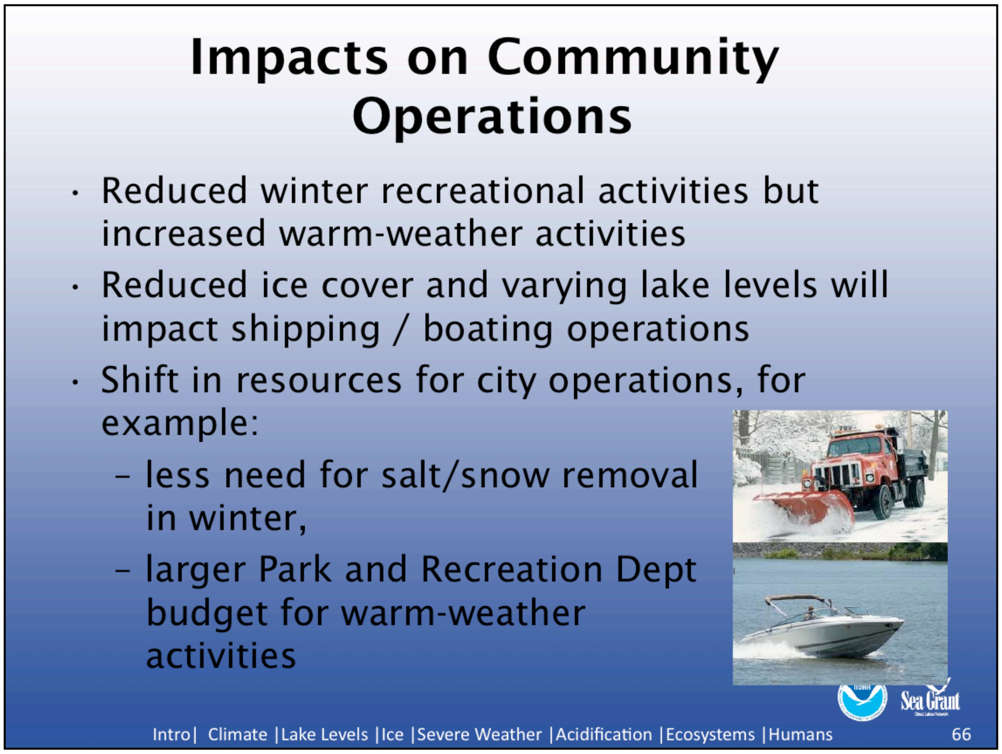
--Shifts in business opportunities: for example, there will be a longer summer vacation season and a longer construction season

Preparing for Climate Change: A Guidebook for Local, Regional and State Governments

http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf

Another potential resource: *Economic Impact Analysis of Climate Change for the City of Chicago*

Images from: greatlakesdayindc.blogspot.com; auburn.edu



Climate change will also pose both challenges and opportunities for community operations. For example, there will be:

Reduced winter recreational activities such as skiing, snowmobiling, ice skating, ice fishing, and ice sailing, but *increased* warm-weather activities such as swimming, boating, golfing, etc.

Less snow and ice will result in *fewer* shipping disruptions in the winter…but on the flip side, varying lake levels may result in *more* shipping disruptions;

City operations may have to shift their resources; for example, there may be less of a need for snow removal in the winter, but more need for an expanded Parks and Rec department to deal with an increase in summer tourism activities.

Images:

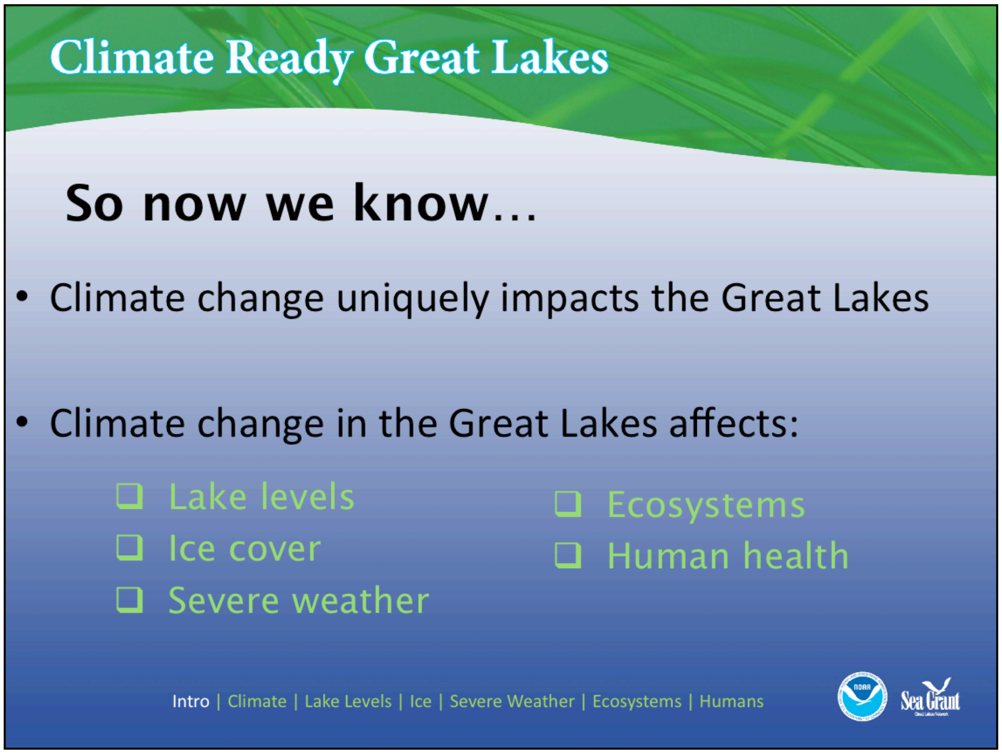
nwk.usace.army.mil; snowremovalservice.org

Sources:

Huntley, Melinda. 2009. “Climate Change and Great Lakes Tourism: Recommendations for Research, Education and Outreach.” Tourism Program Director, Ohio State University Sea Grant Extension.

Human Health and Economy Summary

- Increasing number and intensity of heat waves
- Reduced air quality
- Increased risk of combined sewer overflows
- Shift of crop distribution
- Shifts in business opportunities and community operations



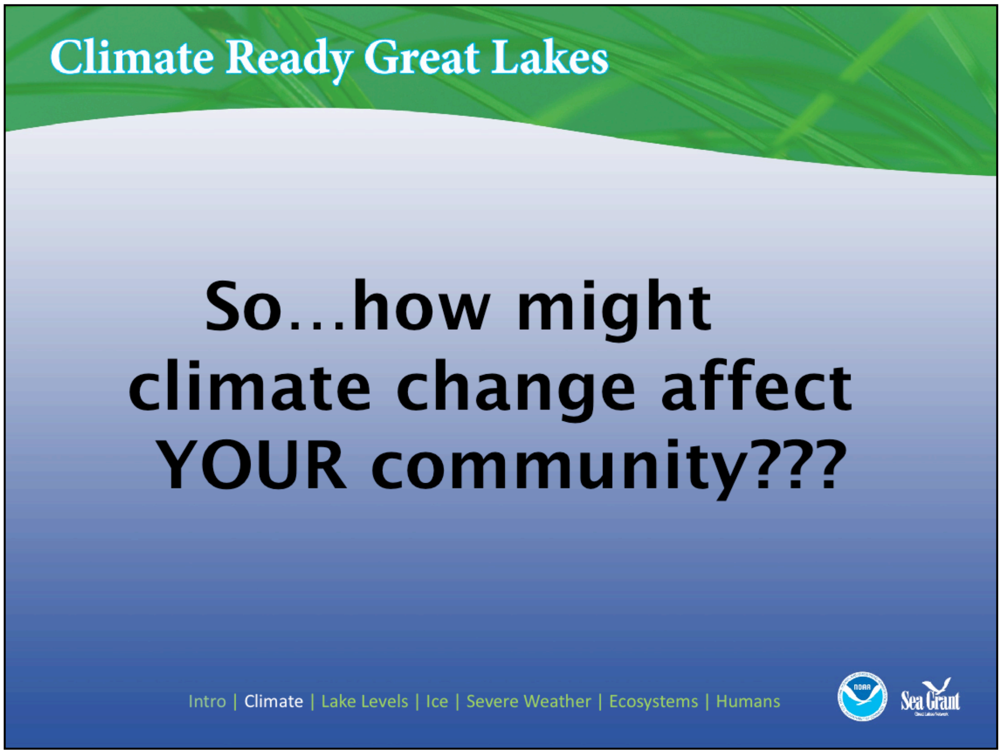
Let's review what we have heard so far. **[click]**

(Pause to let people read about our understanding) **[click]**

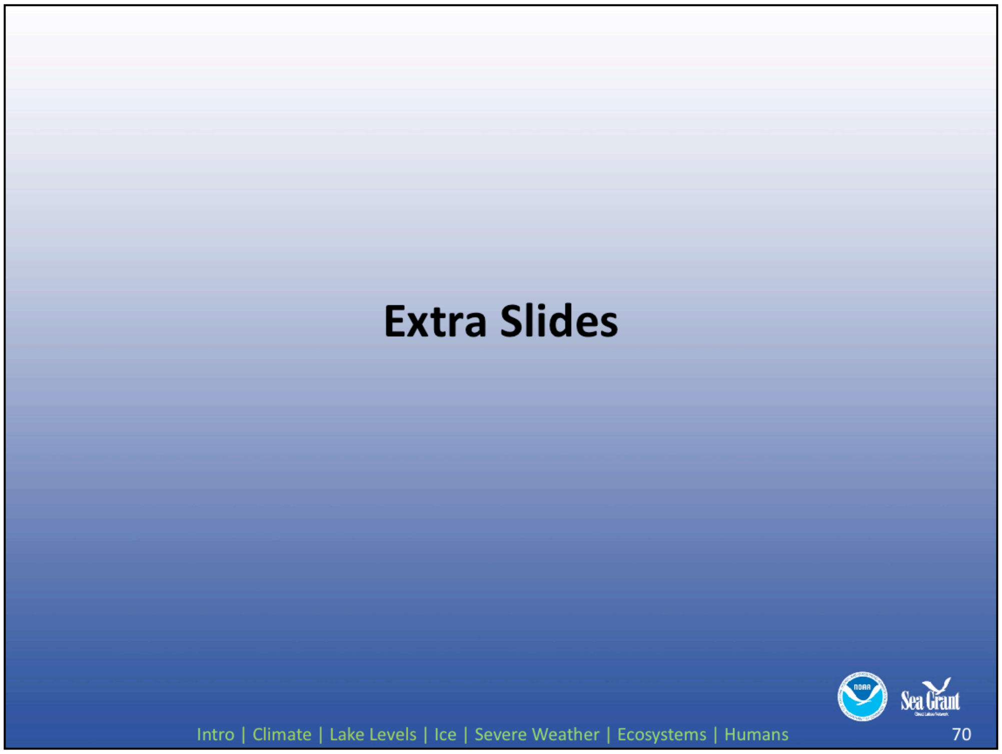
The Great Lakes will have different and distinct climate challenges and opportunities compared to the rest of the country. [click]

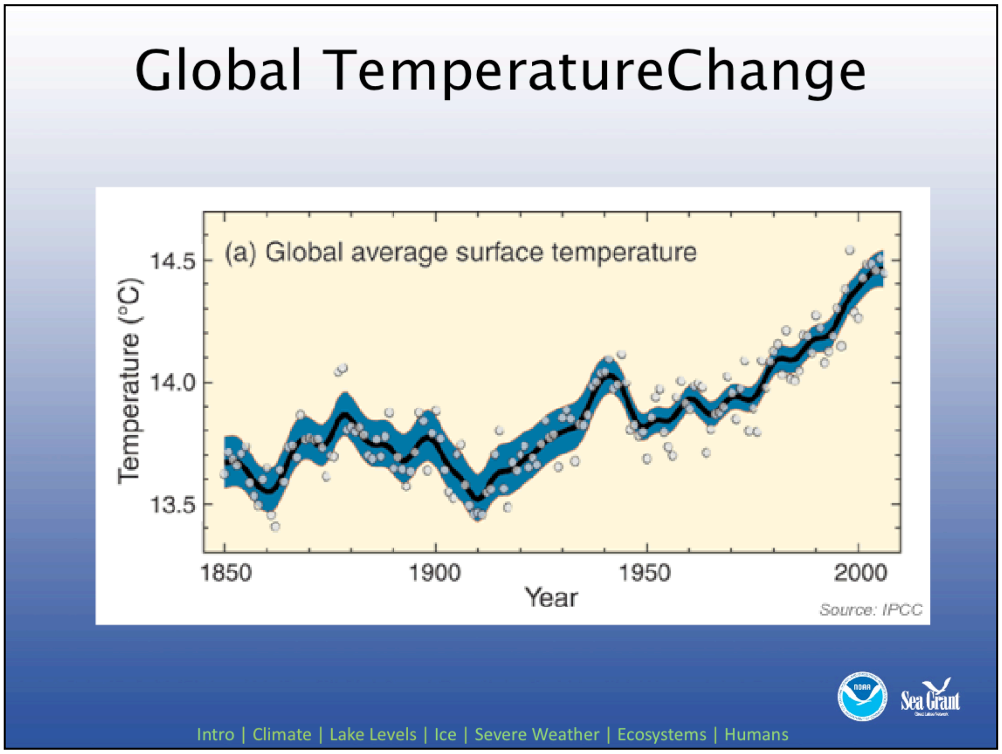
We obviously won't have to cope with sea level rise, but our changing lake levels will create economic and ecological problems. A decline in lake ice is an issue that other parts of the country do not have to face. In other parts of the country, while severe weather may bring hurricanes, we will have heat waves and more rain and flooding. Our species distributions will shift. Open water food webs driven by nutrients provided by lake turnover will change. People will be affected by extreme weather, potential declines in water quality, and agricultural shifts.

The bottom line is that the impacts of climate change will have various effects on life as we know it in the Great Lakes, and we need to be prepared for change.



So what makes climate change impacts in the Great Lakes region different from **GLOBAL** climate change impacts?


Extra Slides
Intro | Climate | Lake Levels | Ice | Severe Weather | Ecosystems | Humans
70



Note: This hidden slide is really a background slide. Previous slides have sufficiently covered global observed temperature changes.

****

As was mentioned earlier in the presentation, one of the impacts of climate change is increasing temperatures.

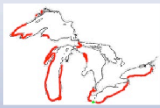
According to observations from the Intergovernmental Panel for Climate Change (IPCC), the average global surface temperature over the last 50 years has increased by 0.13ºC per decade, which is nearly twice as much as the increase over the last 100 years.

Text adapted from: A Report of Working Group 1 of the IPCC. *A summary for Policy Makers.* http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

Image

http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains1.html

Range Expansion Species To Date



Native to Lake Erie – expanding northward

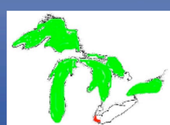
Rusty crayfish

Native to Lake Erie and Huron, invading Lake Michigan

River darter

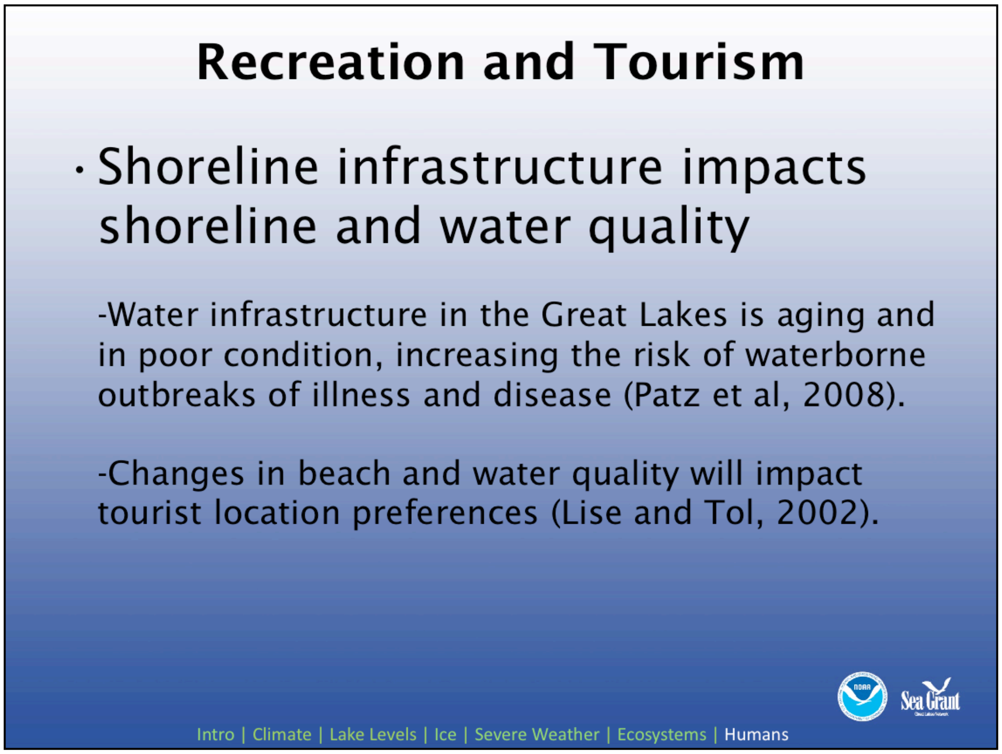
Native to Lake Michigan, invading Lake Erie

Bullhead minnow



Native in Lakes Superior, Michigan, Huron and Ontario; Introduced Lake Erie and Lake St. Clair

Brook trout



*As precipitation events become more extreme, storm and waste water overflow events will likely result in poor water quality, and increased risk to public health and safety. This will impact recreation and tourism in the Great Lakes.

Patz, Jonathan A., Stephen J. Vavrus, Christoper K. Uejio, Sandra L. McLellan. 2008. “Climate Change and Waterborne Disease Risk in the Great Lakes Region of the U.S.” American
Journal of Preventative Medicine 35(5):451-458

Huntley, Melinda. 2009. “Climate Change and Great Lakes Tourism: Recommendations for Research, Education and Outreach.” Tourism Program Director, Ohio State University Sea Grant Extension.

Lise, Wietze and Richard S.J. Tol. 2002. “Impact of Climate on Tourist Demand.” ClimaticChange 55:429–449

Report on Great Lakes Beach Health Research Needs Workshop of November, 4, 2005. Great Lakes Beach Association in cooperation with National Oceanic and Atmospheric Association, United States Environmental Protection Agency, and US Geological Survey

Sturtevant, Rochelle. 2004. “Great Lakes Ecological Forecasting Needs Assessment.” NOAA Technical Memorandum GLERL-131. Great Lakes Environmental Research Laboratory:
Ann Arbor, MI.

Dealing with Uncertainty

This is IPCC's Likelihood Scale. When the IPCC declares a ***likely*** impact of GCC, it indicates a 66% or greater chance of occurrence.

Table 4. Likelihood Scale.

Terminology	Likelihood of the occurrence/ outcome
Virtually certain	> 99% probability of occurrence
Very likely	> 90% probability
Likely	> 66% probability
About as likely as not	33 to 66% probability
Unlikely	< 33% probability
Very unlikely	< 10% probability
Exceptionally unlikely	< 1% probability

Intro | Climate | Lake Levels | Ice | Severe Weather | Ecosystems | Humans

The International Governmental Panel on Climate Change (or IPCC) is a scientific intergovernmental body tasked with reviewing and assessing the most recent scientific technical and socio economic information produced worldwide relevant to the understanding of climate change. A main activity of the IPCCC is the regularly publishing of special reports or assessments of climate change and its impacts. In their reports, the IPCC uses a likelihood scale to describe the probability of occurrence for an event.

When the IPCC declares a likely impact of global climate change (or "GCC"), it is indicating a 66% or greater chance of occurrence.

It is important to remember that uncertainty is a crucial part of any form of scientific research, climate research being no exception. No matter how elaborate our models are or how convincing our observations seem, a degree of uncertainty always exists.

Global Climate Models also help us understand and quantify degrees of uncertainty associated with climate change forecasts.

Climate Change Uncertainties include questions regarding the degree of future Greenhouse Gas emissions, solar output, and variations in ocean circulation patterns.

Sources:

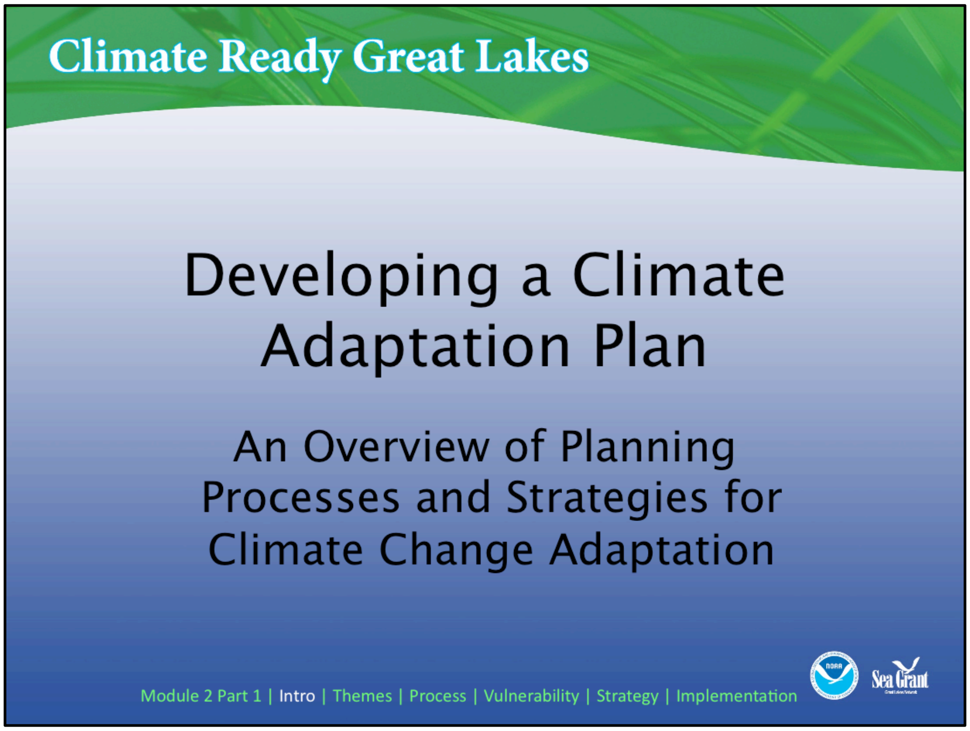
1.) Wesleyan Student Assembly (WSA) -> http://wsa.wesleyan.edu/wp-content/uploads/Question-Marks.jpg

2.) Intergovernmental Panel on Climate Change (IPCC) -> http://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf

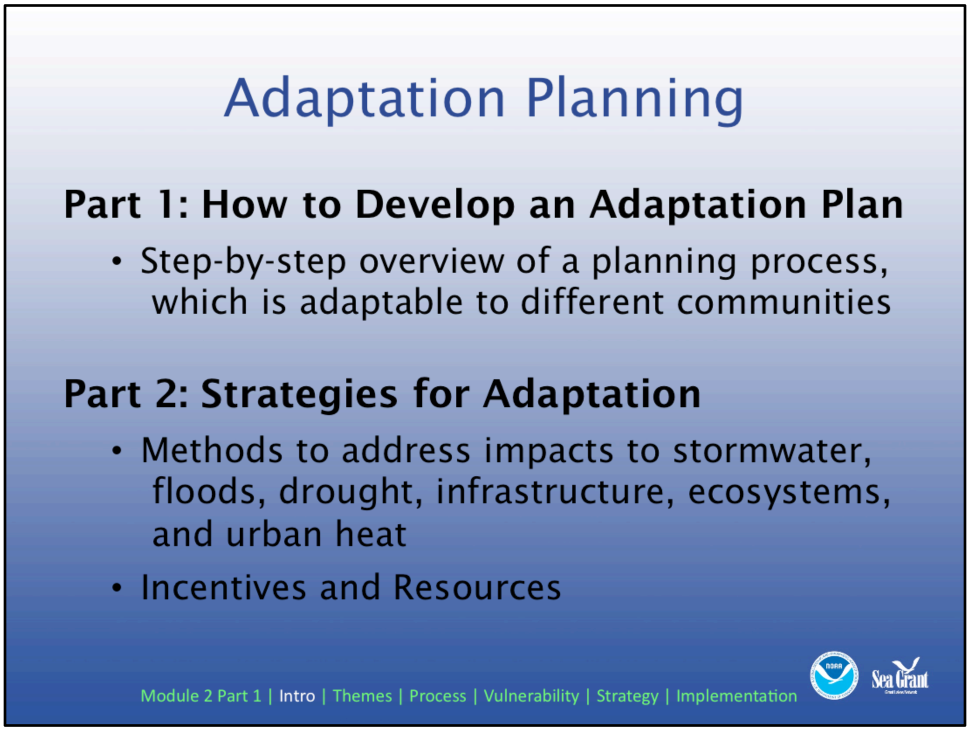
3.) National Aeronautics and Space Administration (NASA) -> http://climate.nasa.gov/uncertainties/


Climate Ready
Great Lakes
NOAA
Sea Grant
Great Lakes Network

1

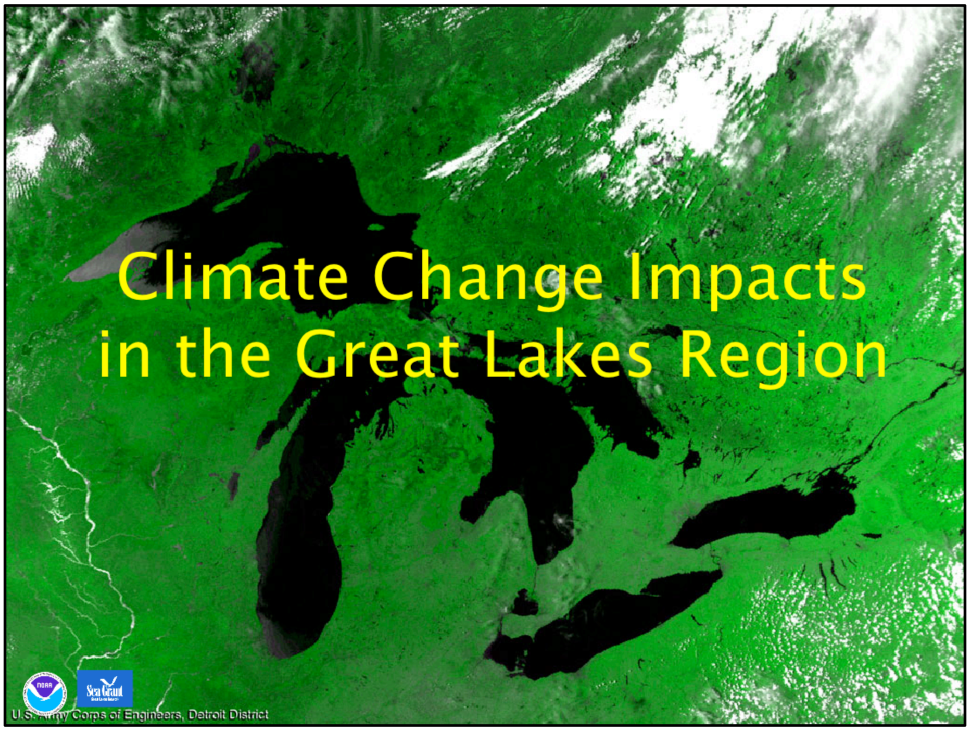


Module 2 describes how to develop a climate adaptation plan that is appropriate for a specific community. It is designed to help people take the broad predictions about how climate change will affect the Great Lakes region and consider what this means for their own area. Once the focus has been narrowed down, it is possible to determine what strategies may be most appropriate for the community.



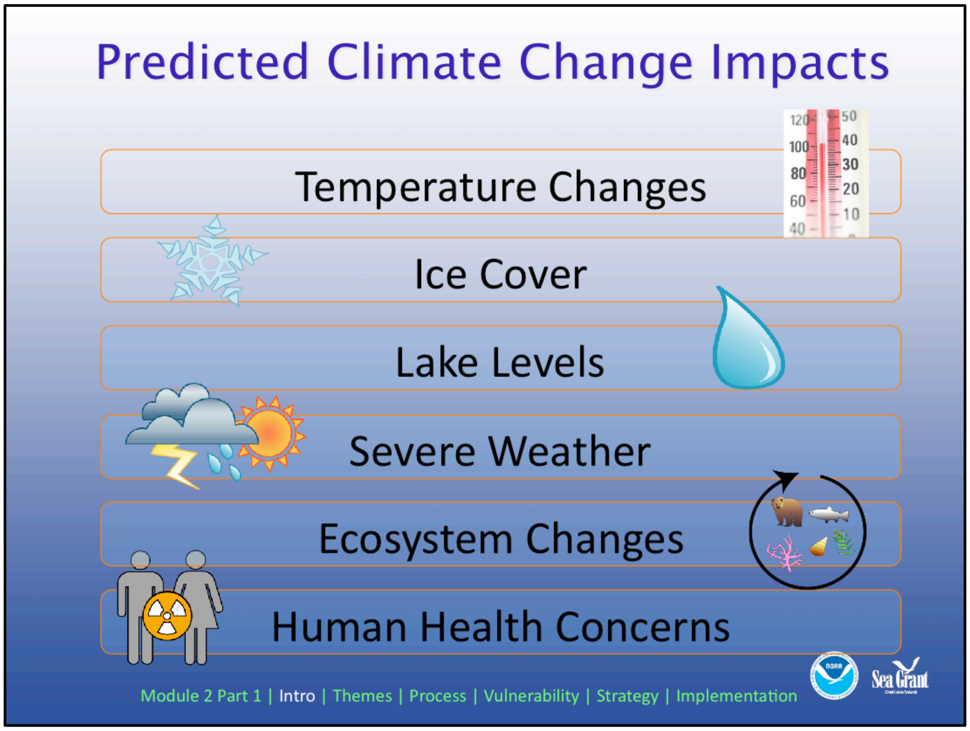
The presentation has two parts:

1) The first part describes a planning process focused on developing a plan for climate adaptation. This is based on the process used in Chicago, but it is adaptable to different communities. Part 1 provides insights from real-world case studies to lay a foundation for thinking about how these processes may be applied.
2) The second part describes some of the strategies that can be incorporated into an adaptation plan to address specific topics related to the predicted impacts of climate change for the Great Lakes region. This includes a final section on incentives and resources related to policies at community, state, and federal levels.



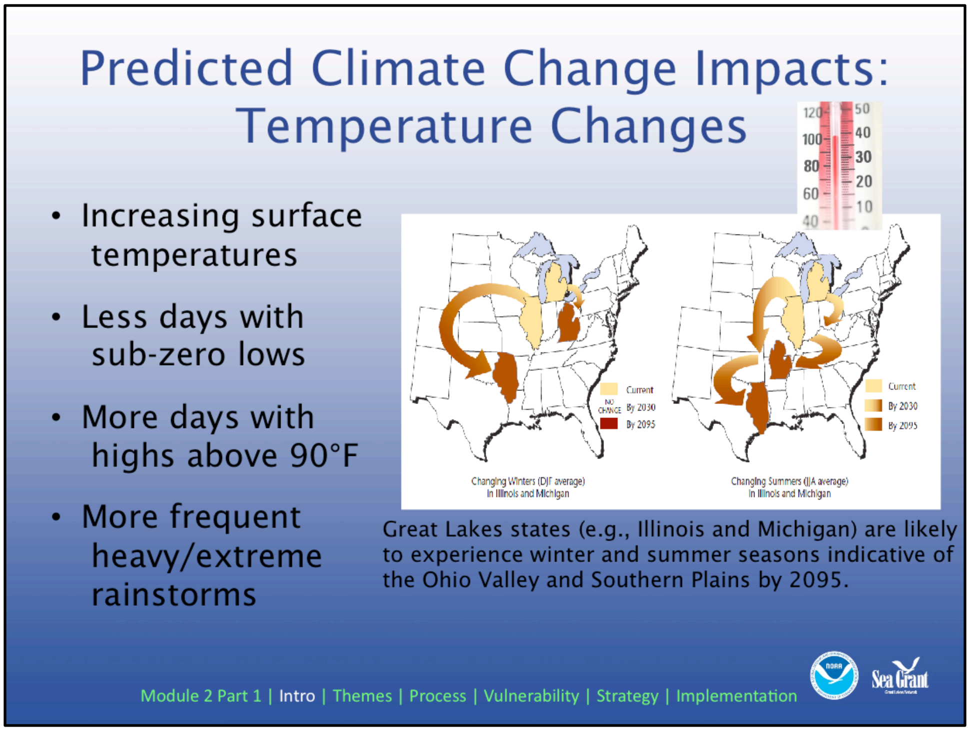
The following slides provide a brief review of the predicted impacts of climate change in the Great Lakes Region.

These can be used to to remind people of what they learned in Module 1.



Climate change is a global phenomenon, but its effects are seen at a regional scale. There is a wealth of knowledge about climate systems, but regional-scale systems are still under development and require improvements in scale and certainty. However, it is clear that…

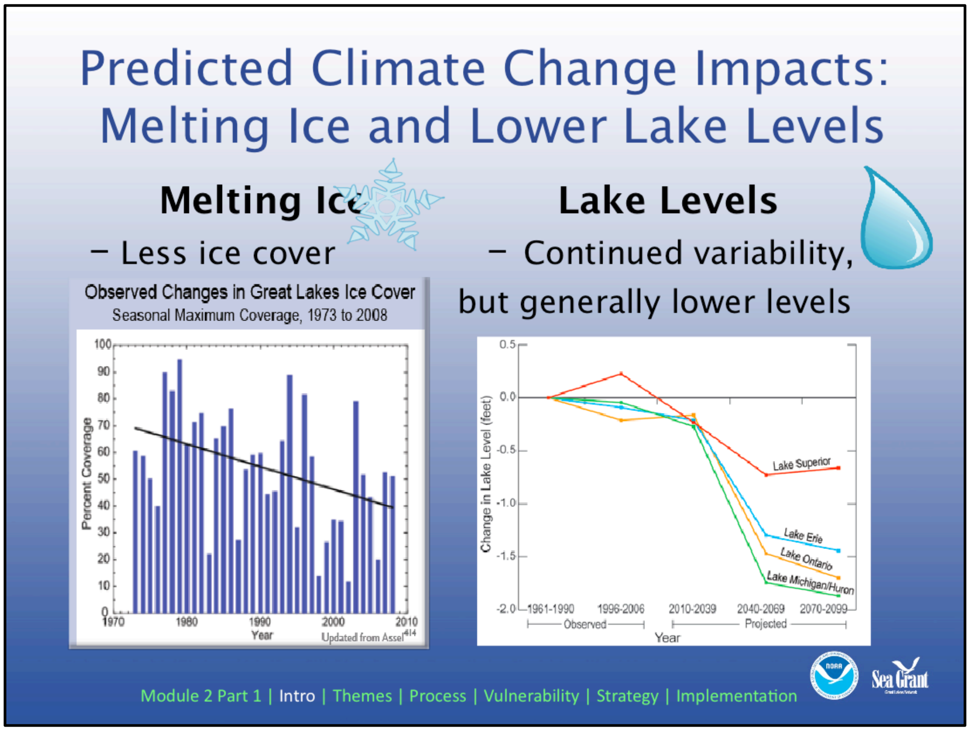
Climate change will have consequences for the Earth system and human lives. Impacts resulting from climate change will affect temperature, ice cover, lake levels, severe weather, ecosystems, and human health.



- Over the next century, wintertime surface temperatures are likely to increase 6–13°F, while summertime surface temperatures are likely to increase 8–18°F. The largest increases will likely occur over western portions of the Great Lakes region.
- The number of days with sub-zero lows is likely to drop by 50% or more, while the number of very hot days (highs > 90°F) is likely to double or even triple. For example, by 2095, Detroit may annually have 35–50 days with highs above 90 degrees, including several days over 97 degrees.
- Extreme or heavy rainstorms are likely to become 50–100% more frequent by 2095, making flash flooding a real possibility.

The figure depicts what Illinois' and Michigan's climate systems (both winter and summer) might look like by 2095 AD.

Figure credit:
Union of Concerned Scientists (UCSUSA)
http://www.ucsusa.org/assets/documents/global_warming/color_figures.pdf

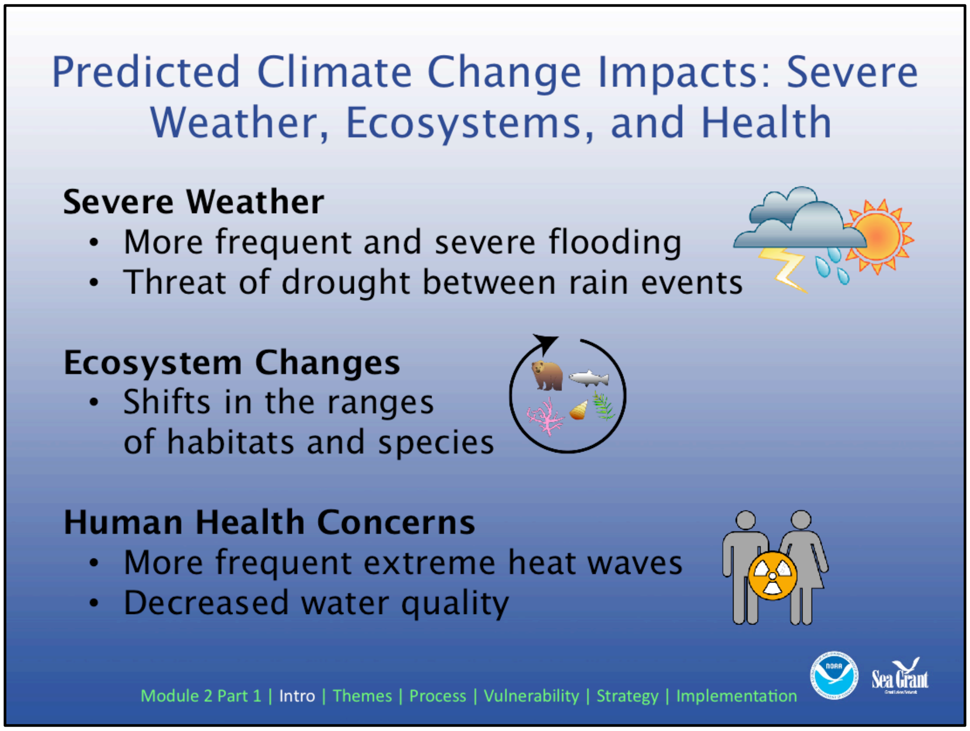


A reduction in seasonal ice cover on the Great Lakes is a predicted impact of rising temperatures. The black line on the graph of Great Lakes' ice cover shows a clear decrease in the extent of ice cover since the 1970s, even though there are large year-to-year variations.

Higher temperatures cause more evaporation, which will likely result in reduced water levels in the Great Lakes. In winter, reduced amounts of lake ice also increases evaporation and contributes to the water level decline. Under a lower emissions scenario, water levels in the Great Lakes are projected to fall no more than 1 foot by the end of the century; however, they are projected to fall 1–2 feet in a higher emissions scenario. The greater the temperature rise, the higher the likelihood of a larger decrease in lake levels.

Climate factors like temperature, wind speed, evaporation, precipitation, humidity, and solar radiation cause Great Lakes water levels to naturally fluctuate. Current models show that by the end of the century lake levels are much more likely to be lower, although the models also indicate a high degree of uncertainty.

Source: "Global Change Impacts in the United States, Midwest Report", United States Global Change Research Program
http://www.globalchange.gov/images/cir/pdf/midwest.pdf

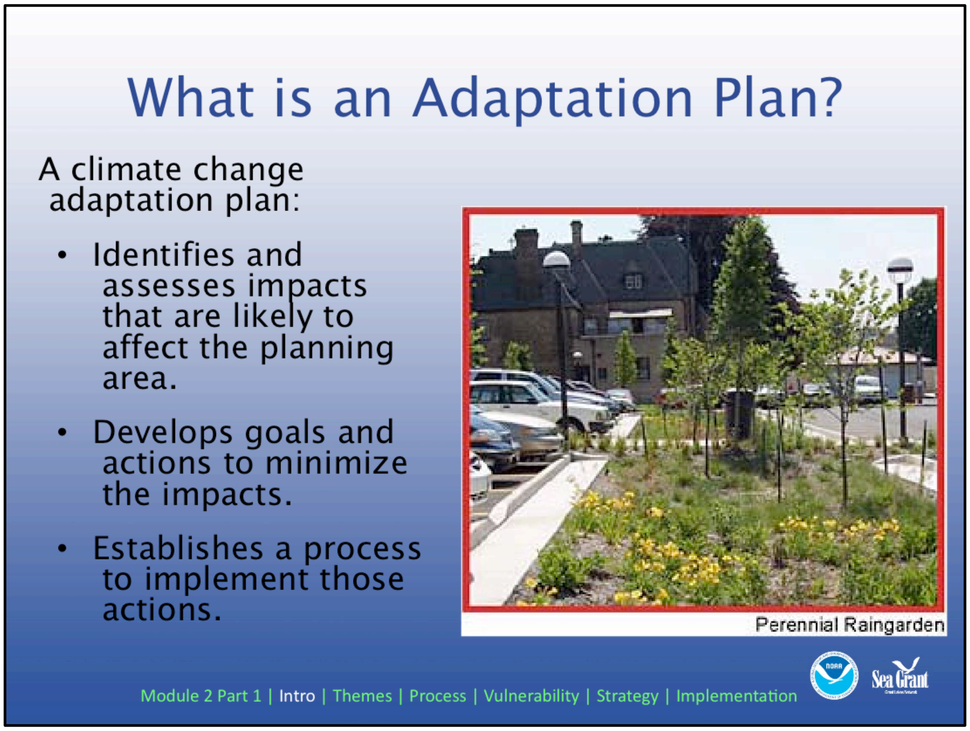


In the United States, extreme weather events have made up a disproportionate share of the observed increases in total precipitation. For example, the number of days with precipitation greater than two inches has increased (Karl, T.R., R.W. Knight, D.R. Easterling, and R.G. Quayle. 1996. "Indices of climate change for the United States." *Bulletin of the American Meteorological Association* 77 (2): 279-292). Increases in precipitation accumulations have been the greatest in the Great Lakes, Southwest, and Midwest regions (IJC. 2003. *Climate Change and Water Quality in the Great Lakes Basin*.)

High amounts of precipitation within a short period of time are considered *extreme precipitation events*. These events create risks for flooding, erosion, water quality deterioration (e.g., entrainment of pollutants and sewer overflow), and human health concerns (e.g., more frequent outbreaks of water-borne diseases, especially in rural areas). Even though extreme precipitation events may occur more frequently, the threat of drought may also increase in the Great Lakes region due to warmer temperatures and increased evaporation between rain events. As temperatures increase, the loss of soil moisture between rain events due to evaporation could be more significant than increases in rainfall.

The Great Lakes region includes numerous ecosystems and habitats (such as coastal wetlands, northern hardwood and coniferous forests, beaches, and dunes). Many of these habitats have been stressed or altered by human activities over time. Additionally, relatively small changes in temperature or water levels can have a cascading impact throughout the system: as habitats become drier, species will shift locations to remain in their preferred temperature range. These shifts can alter the relationships between species and how they use their habitats. One of the major impacts of rising temperatures in the Great Lakes region will be territorial shifts as species expand to the north. Numerous studies are documenting movements by species as they seek out the best conditions for their survival.

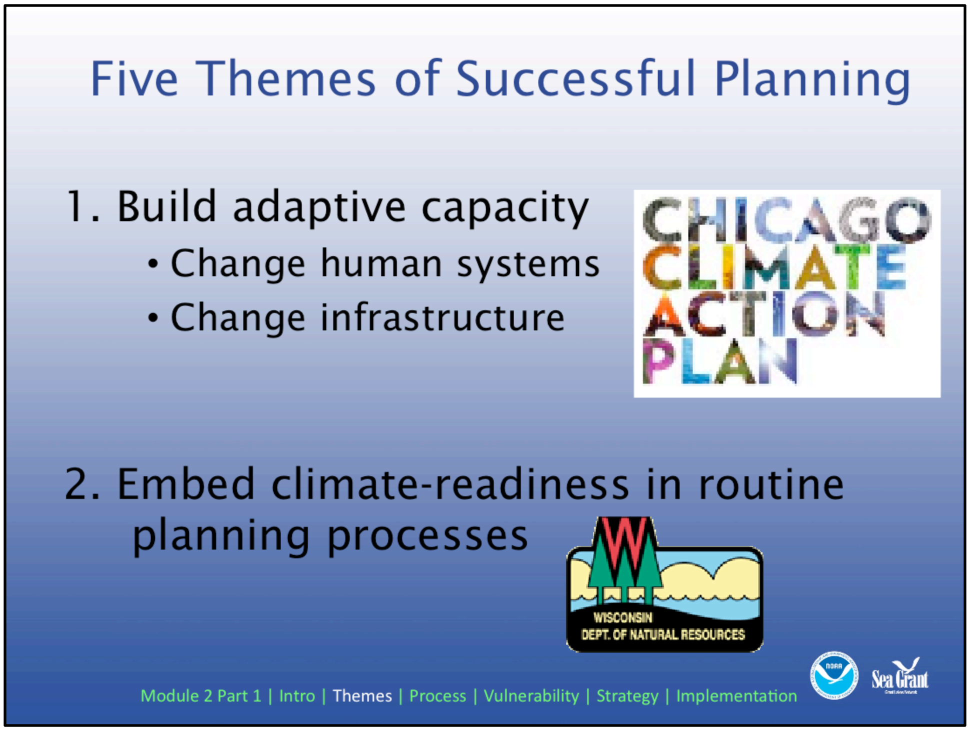
More frequent extreme heat events are also expected over the next century as a result of climate change. More frequent extreme precipitation events could affect water quality by causing increased runoff into streams and lakes and an increased chance of combined sewer overflows.



Adaptation Planning starts with an analysis of how the predicted impacts of climate change will affect the local community. Once these are understood, it is possible to decide on the best options for reducing those impacts. An effective plan will incorporate adaptation into other elements of community planning to increase the chances of successful implementation.

As noted in NOAA's *Planning Guide for State and Coastal Managers*, "While an adaptation plan … may stand alone, planning to adapt to climate change should be incorporated to varying degrees in all statewide planning efforts (as well as regional and local planning efforts)." The ultimate goal is "coastal states and communities that are organized to take action, have the tools to take action, and are taking action to plan for and adapt to the impacts of climate change."

Definition of Adaptation Plan from NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers*.



Chicago has worked extensively to prepare for climate adaptation, including documenting the planning process used for the city. Chicago is making the results of its research available for other communities to use in their own planning efforts. Although rural and smaller towns will need some different kinds of information, there are currently very few cases of climate adaptation planning from small towns on which to draw.

This idea of connecting adaptation planning to existing municipal structures is one of the themes that Chicago planners stressed as a lesson they learned in their Climate planning process. In these "Five Themes of Successful Planning" the authors discuss the practical challenges they faced. Because adaptation means changes to human systems and infrastructure (1) it must be incorporated into the all of the city's planning (2). Theme 4 stresses that small steps are more politically viable, but that this is actually appropriate for climate planning since our knowledge of climate change impacts is continually improving (5) and this means that plans may need to be modified frequently.

The *Chicago Climate Action Plan* includes five themes for successful planning that are useful for all planners to keep in mind:

1. "[B]uilding adaptive capacity is the putting in place of support systems, data collection, evaluation processes, awareness-raising, and policy framework(s) which will encourage, allow or require individual businesses and regions to undertake adaptation. Only when such work has been undertaken in a particular organization or sector can the work of delivering adaptation actions begin."

2. Climate change will affect elements of community infrastructure and life that are already addressed by municipal planners and existing organizational structures. Planning for climate change is not about starting from scratch; it is about adding climate considerations to the existing short- and long-term community plans.

   "Planning processes identify future organizational, operational, equipment, or infrastructure needs involving procuring new goods, services and/or products or building new infrastructure that must function under a new set of climate conditions. To manage risk, planning processes should be modified to account for potential impacts of climate changes."

For example, New Zealand has issued guidelines for local authorities that include specific questions to be asked when drawing up individual plans, including:

- Does the risk management analysis take into account changes due to climate change?
- Do the effects of climate change reflect the current level of uncertainty in the region and should a cautious approach be adopted as a result? If not, is this explained?
- Does the plan include a specific commitment to keep up to date with changing understanding of climate change and its implications (including any relevant local monitoring or liaison)?

Chicago Quick Guide to Climate Change Preparation p. 6.

3. Adaptation measures almost always have multiple benefits (such as reduced energy costs, improved aesthetics, and reduced air and water pollution). These should be considered to assess the overall benefit of the measures that may be taken—especially when the co-benefits either save money or outweigh the costs of the measures.

Chicago Quick Guide to Climate Change Preparation

4. Incremental steps (rather than large actions) keep options open so that plans can be adjusted as new data develops. Phased projects can help communities avoid getting locked into trajectories that may not be compatible with future climate risks. Phased projects are also easier to incorporate into existing community plans and are less politically difficult. Furthermore, distributed infrastructure can be more flexible in responding to change than large, centralized systems.

5. "The paradox of process planning is the intermixed integration of past, present, and future. We plan for the future, do so in the present, and use data from the past." To plan for climate change, new data must be continually incorporated and decisions reassessed.

Chicago Quick Guide to Climate Change Preparation

The outline for the planning process described in Module2 has Four Steps. These are similar to many urban planning processes.

Step 1 focuses on establishing the planning process.
Taking time to define the planning process helps clarify and streamline planning. It also promotes appropriate representation of stakeholders, inclusion of decision makers, and access to resources.

This adaptation planning process is from NOAA's *Adapting to Climate Change: A Planning Guide.*

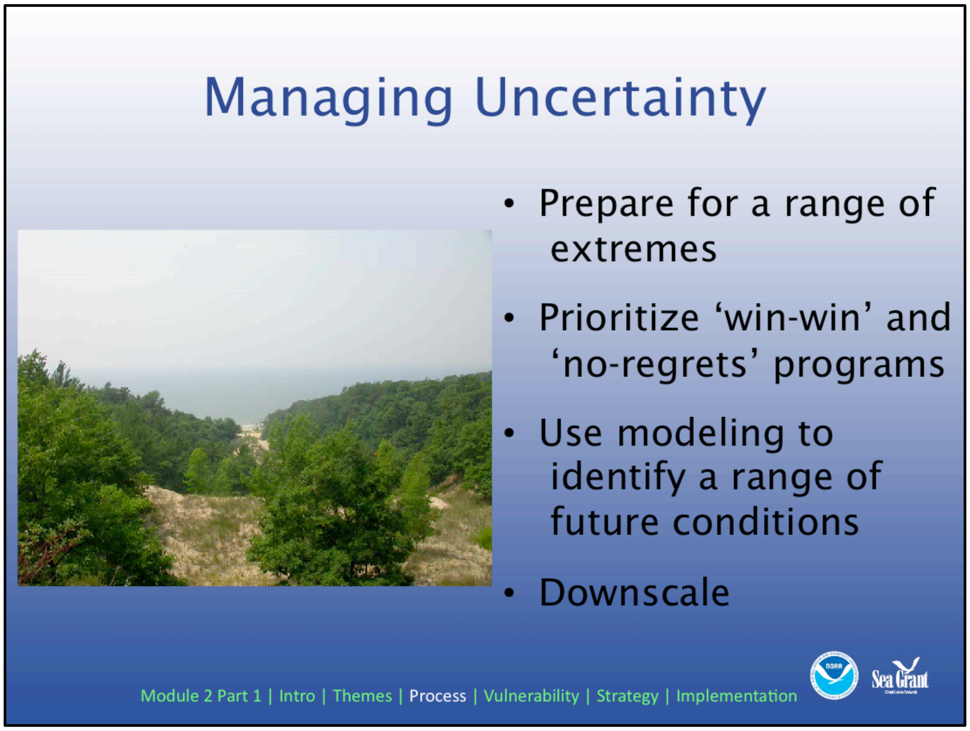
Every community is unique, so it is necessary to start by determining what your community needs/wants to do. Use NOAA's Module 1 to present information on the predicted impacts of climate change for the Great Lakes and the science involved in developing these predictions.

Readiness means anticipating and planning to avoid potential future impacts and conflicts. For example,

- Preparing strategies for competition for water in dry years
- Avoiding land use/development with problematic consequences
- Preventing development in shorelines exposed by low water

Waiting until information is completely certain increases risk, so climate change planning requires action and planning with imperfect information.

Cities and municipalities already make other plans and decisions based on uncertain information. For example, population growth, natural disasters, flood insurance programs, and disease control are all based on uncertainty.



Even though plans need to be made based on imperfect information, there are ways to manage the uncertainty:

- Prepare for a range of extremes, but revise plans as information improves.
- Prioritize and focus on 'win-win' and 'no-regrets' programs (such as ecosystem conservation and energy reduction programs).
- Use modeling to help identify a range for future conditions—as well as significant uncertainties.
- Downscale to reduce the amount of uncertainty (such as measuring water availability in a city).

PPT slide courtesy of David MacNeil (Sea Grant)

Developing a Community Vision Statement

- Develop a shared vision for the community
  - What should it be like in 20 years? In 50 years?
- Act instead of react (i.e., anticipating and preparing)

Will the Tulip-time Festival in Holland, MI, be earlier in the spring?

Module 2 Part 1 | Intro | Themes | Process | Vulnerability | Strategy | Implementation

Having a clearly defined goal is important for the success of plan development. Including public voices in the visioning process builds ownership, which facilitates implementation of a plan.

Example: Holland, MI, holds a Tulip-time Festival during the first week of May every year. This event celebrates the town's Dutch heritage and is important to the community's identity. Occasionally, spring weather causes the tulips to finish their bloom early and people joke about a "stem" festival. If climate change increases the frequency of these early bloom years, the date for the festival may need to be shifted forward to April, in spite of tradition.

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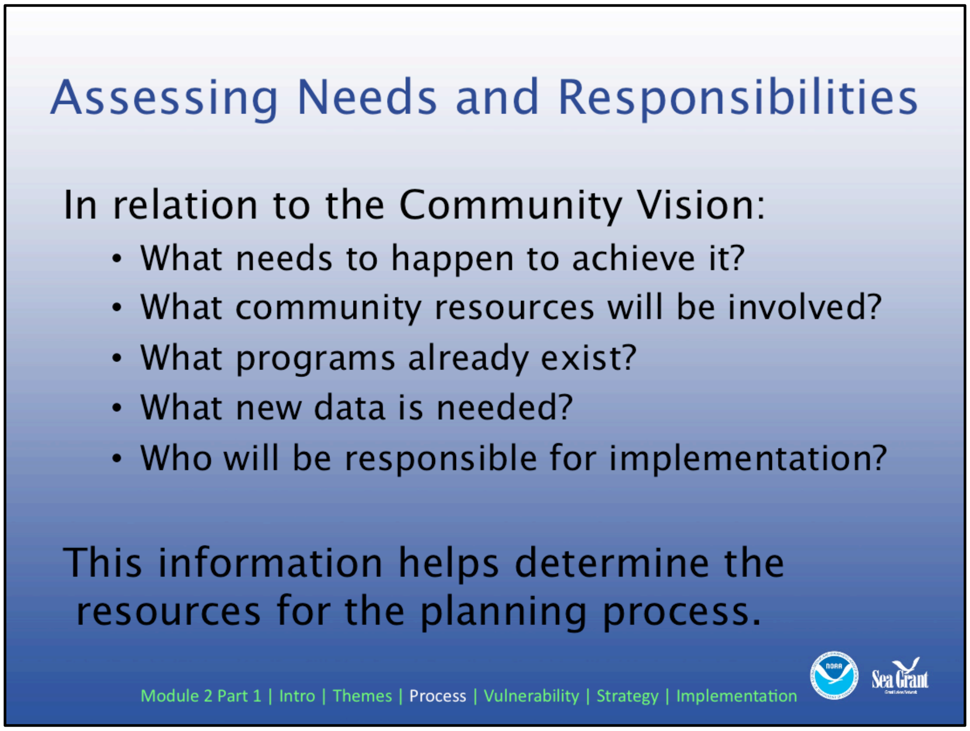
-Some examples of why anticipating instead of reacting is advantageous were presented in the notes for slide 14. If it seems to fit the flow of your presentation better, they can be included here instead.



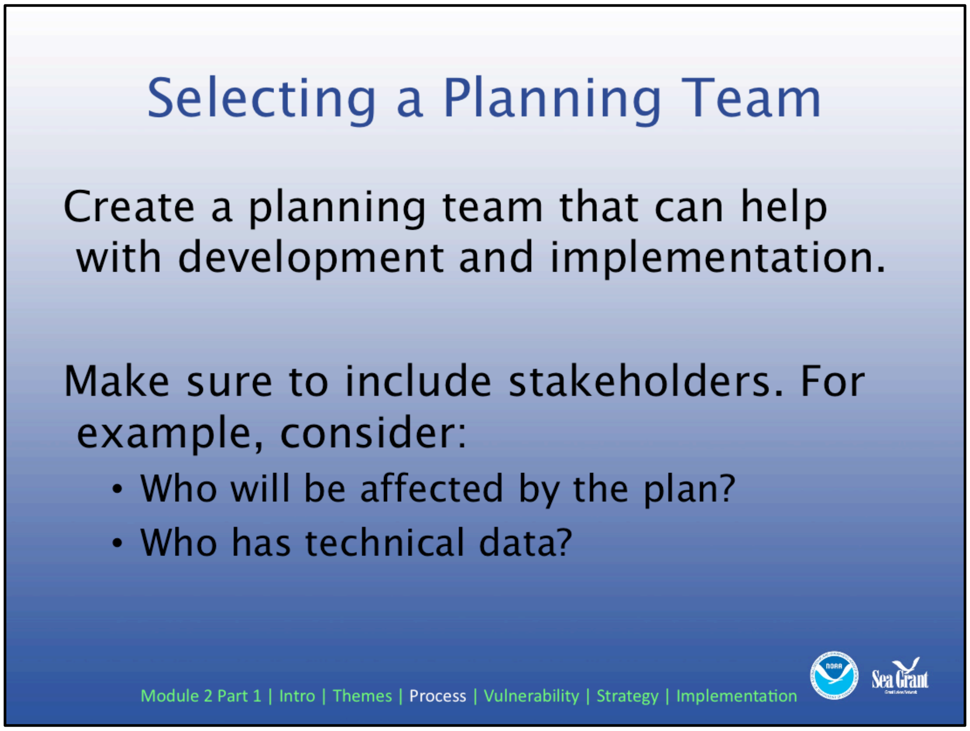
It is important to be clear about (1) what the plan aims to accomplish and (2) who needs to be included in the process in order to accomplish it. Figuring this out at the beginning of the process saves trouble later.

For example, Chicago began its planning process with the idea that the Department of Environment's Climate Task Force would issue the plan. However, part way through the planning process, it was decided that the City had to have ownership of the plan and be responsible for presenting the plan to the citizens. "In this way, the plan could provide a blueprint for action that had the full support of city government and accountability for implementation." If they had started with this idea, they would have included more of the municipal decision makers in the planning process from the beginning.

Julia Parzen. July 2009. *Lessons Learned: Creating the Chicago Climate Action Plan.* www.chicagoclimateaction.org

Having a designated person (and/or a couple of part-time workers) to keep track of the process is important. It provides consistency as the process shifts from phase to phase and other participants move in and out of the process. Without a coordinator, the process is not likely to succeed. In Chicago, a commissioner from the mayor's office oversaw the process, but he had part-time help from staff in the Department of Environment and a representative from a city philanthropic organization.

Whether to select the planning team or the planning coordinator first depends on the community. Although it may be ideal to start with a team, a successful planning process usually requires a "champion" to set things in motion and keep up the momentum. Thus, setting up leadership may be a necessary first step.



The planning team should be diverse, including representatives of agencies that will have to deal with infrastructure and municipal services affected by climate change, business owners, local college researchers, state environmental departments, and elected officials. The team could also include representatives from neighborhood associations or community organizations. If these community voices are not included on the team, they need to be brought into the process through public adaptation meetings.

It may not be necessary to create a new, stand-alone climate change program. Communities may have (1) existing programs that already address many areas affected by climate change or (2) sustainability plans that can be expanded to include climate change. "Plans in your state that may relate to climate change adaptation include, but are not limited to, hazard mitigation, watershed management, wildlife, emergency operations, transportation, economic development, and growth plans."

NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*

Adaptation Planning Benefits from Collaboration

- Linked agency efforts
- Effective solutions as a result of a range of actions by multiple groups
- Shared resources
- Resolving differing perspectives by participating in shared research

Module 2 Part 1 | Intro | Themes | Process | Vulnerability | Strategy | Implementation

Collaboration is appropriate for climate adaptation planning processes for several reasons:

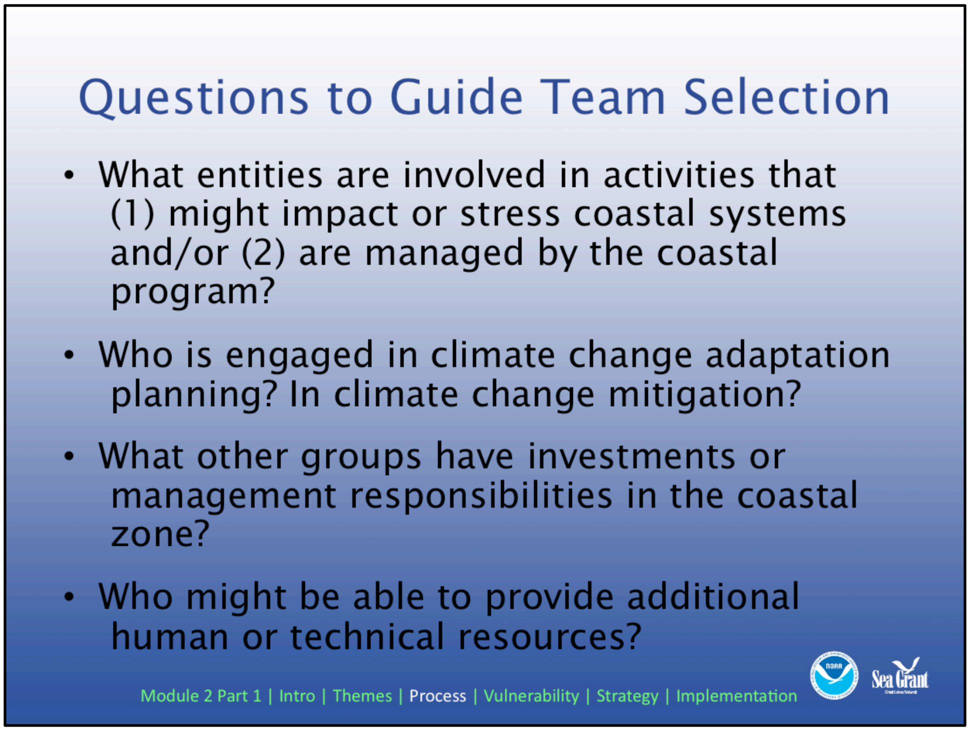
•Implementation of the plan will require cooperation across agencies and authority parameters

•Adaptation efforts benefit from coordination to share limited resources

•People are more likely to participate in implementation of plans if they have ownership of the issues and resources. Stakeholders prefer to have a role in making decisions (instead of feeling like they are suffering under an imposed mandate).

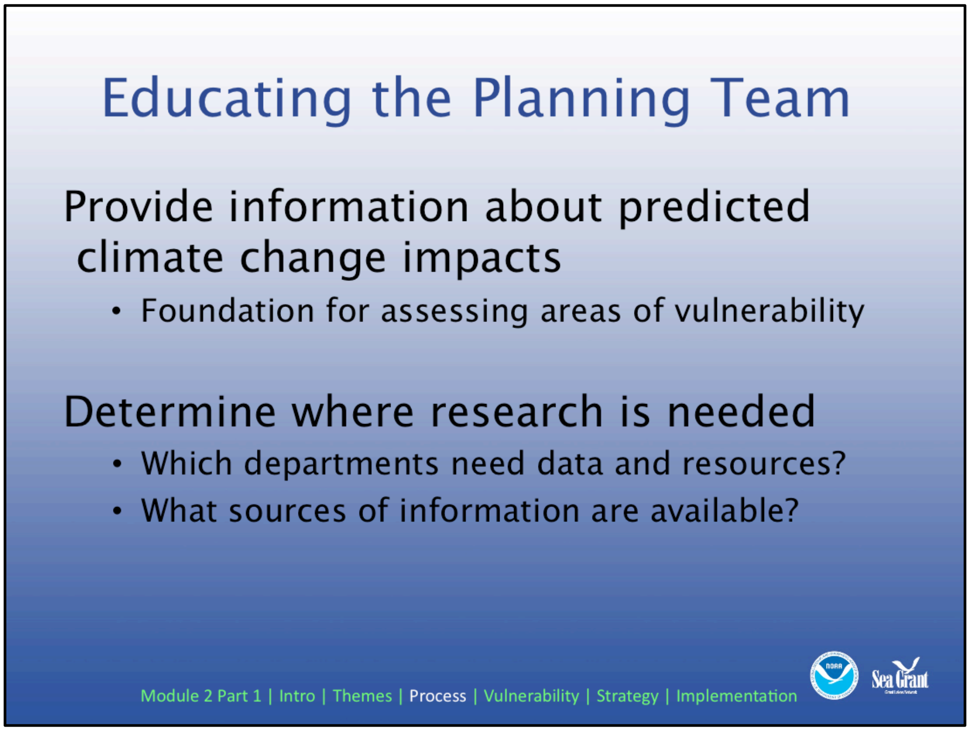
•Some of the differing perspectives about climate change may be resolved by including agnostics in the research process; however, full-scale deniers are not likely to change their opinions. Of course, collaboration cannot work if the parties involved do not want to collaborate.

Information on when collaboration is appropriate derived from *Making Collaboration Work* by Julia Wondolleck and Steven Yaffee.

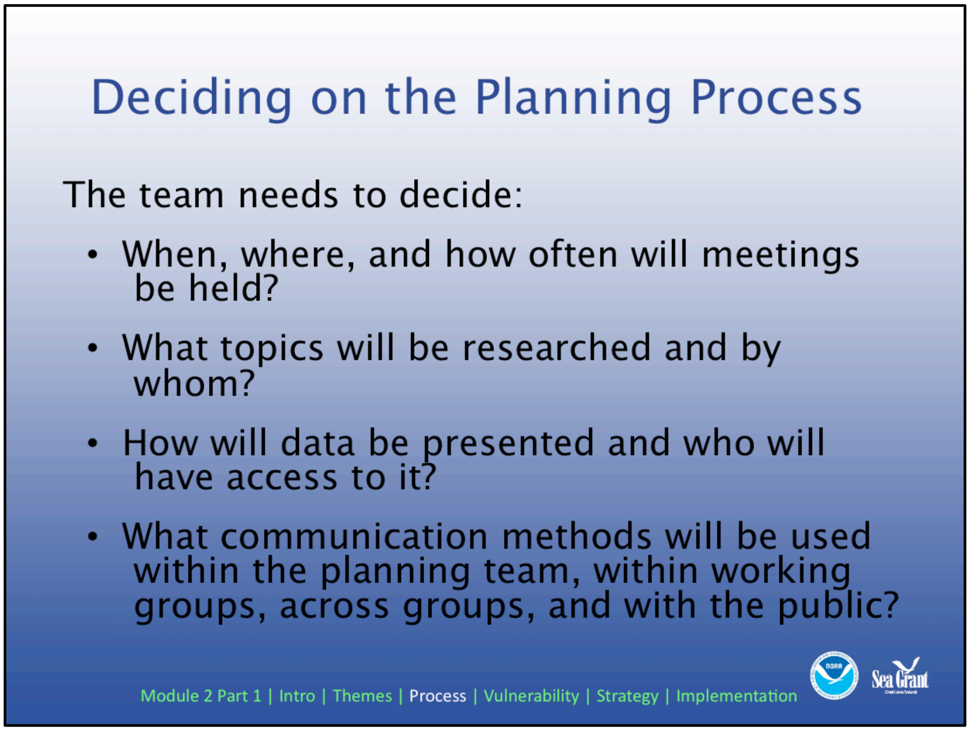


When considering who to include on a planning team, think about who is already active in coastal management, who has useful knowledge, who is already doing work that will be affected by climate change impacts, and who has technical resources that could be of value. Bringing together people with knowledge and technology resources helps with plan implementation. Current mangers who have decision-making authority need to be included if the process is to transition from plan to action. People who are outside the governing system but have a vested interest in coastal areas may be valuable because they can bring strong personal motivations and help build community support.

From NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*



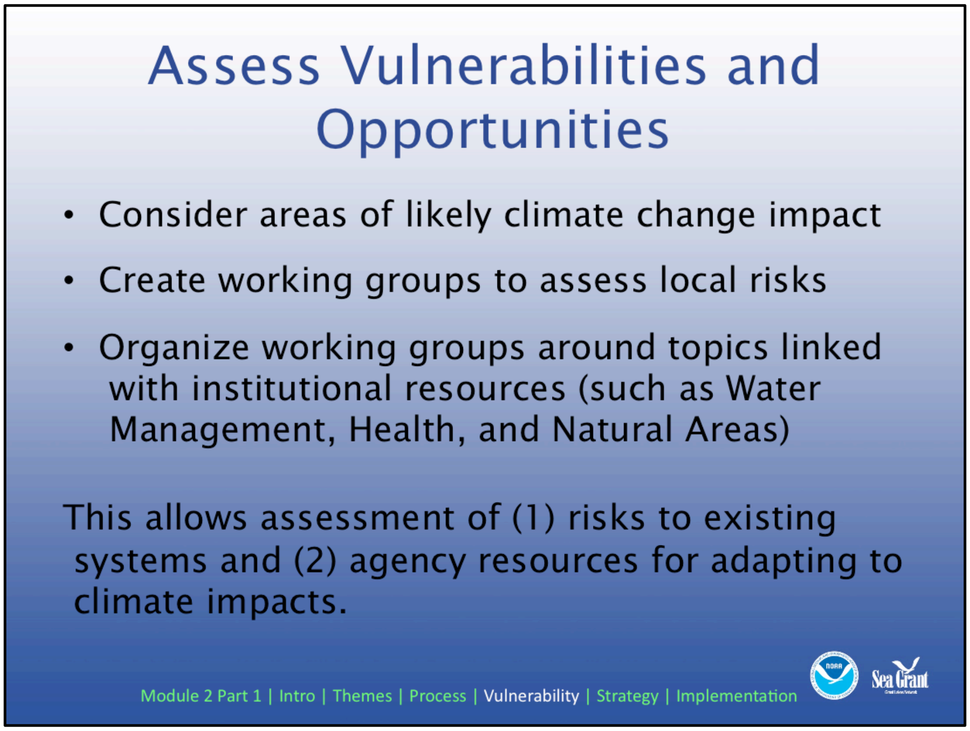
The team needs knowledge about the predicted local impacts of climate change in order to determine what topics need to be researched further. This begins with information about the general predictions of climate change for the region and then considerations of what that means for the specific community. In other words, what aspects of life in the community are vulnerable to the effects of climate change? Once the team has a sense of how climate change might affect the community, they can determine what municipal departments will have to deal with those impacts. These departments will need data and resources in order to respond to the predicted impacts. This, in turn, helps the team decide where to look for information about how to adapt.



Having a regular schedule for meetings creates momentum and improves group dynamics. Establishing guidelines for communication is vital to preventing misunderstandings. There should be a clearly defined method for sharing data within the planning committee so all have access. Designating a channel for interaction with the public helps avoid miscommunication and damage from rumors.

Step 2: Assessing vulnerability/risks and opportunities that climate change may bring to the community.
This step starts to take the general predictions about regional climate change and focus on what those mean to a specific community.

This adaptation planning process is from NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*

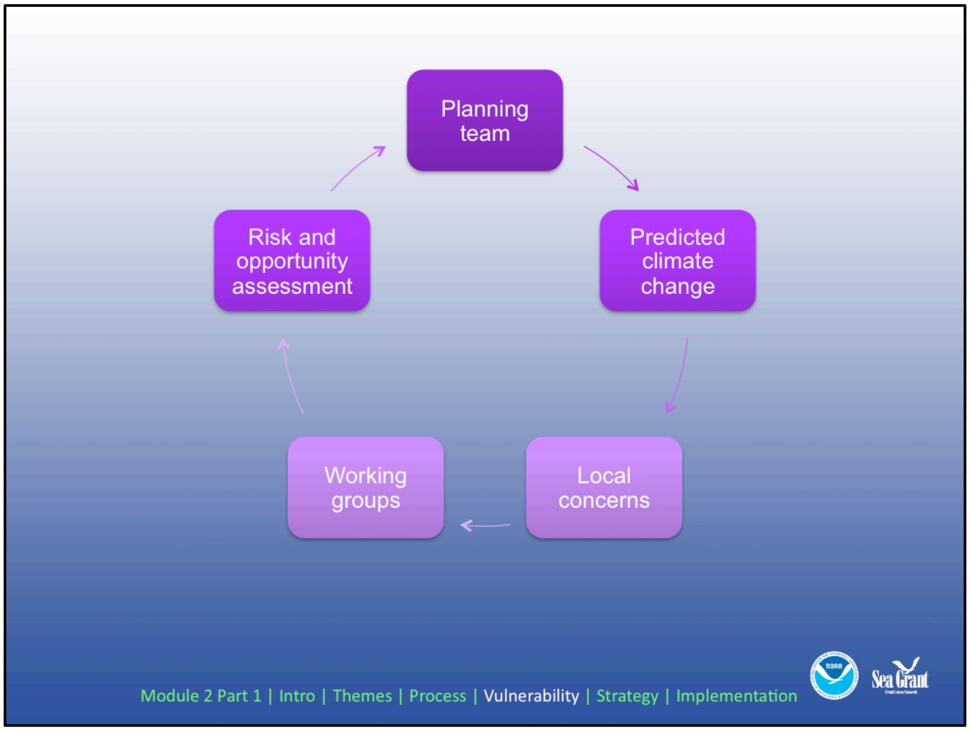


Step 2 focuses on the needs of the community.
Consider how the predicted climate change impacts will affect the area and create working groups to research the local risks. E.g. If heavy rains already cause occasional floods, then increased frequency of extreme weather events may exacerbate that problem. A working group can research the likely effects. Working groups can be organized around specific risks (e.g. flood) or municipal departments (water management). The latter works well because it connects to existing resources of knowledge and may involve the people who will be best able to plan strategies for adaptation.

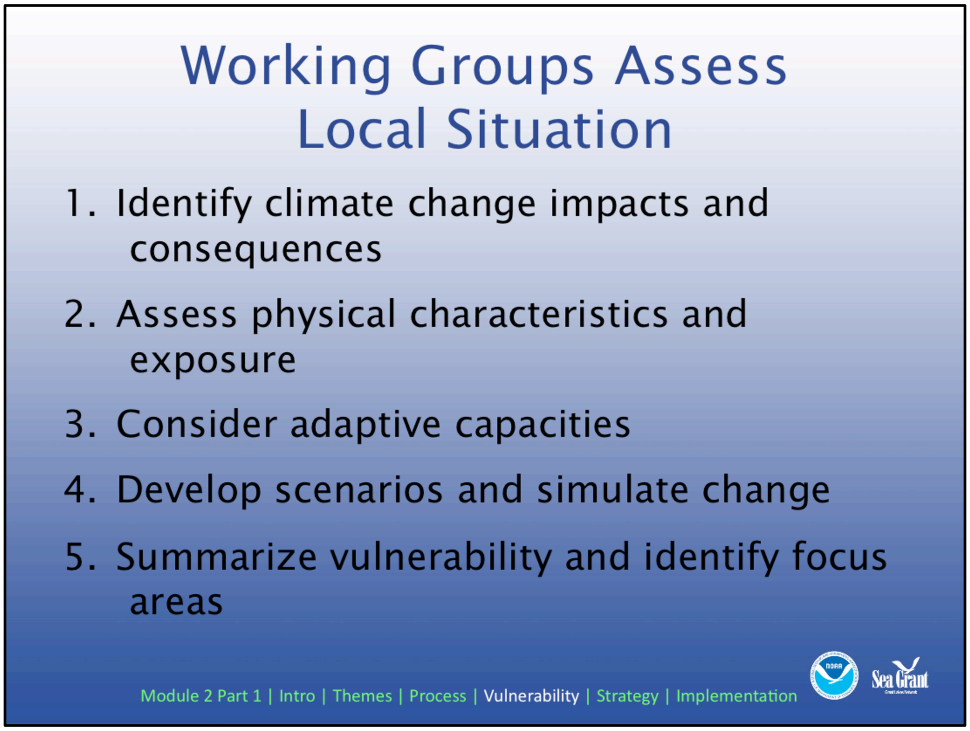
When considering areas of likely climate change impact, Chicago used four themes (Water, Health, Ecosystems, and Infrastructure) and then identified subthemes within each group. The city wanted to know how climate change would impact each of these areas. For example,

- Water's subthemes included precipitation, river flow, and Lake Michigan.
- Health's subthemes included heat, air quality, and vector-borne diseases.
- Ecosystems' subthemes included natural vegetation, animals, invasive species, and agriculture.
- Infrastructure's subthemes included heating and cooling, operation and maintenance, labor, and other.

Although the primary focus of adaptation planning is on risks, climate change may also create new opportunities for a community. E.g. a longer growing season may increase agricultural yield and potentially benefit the economy. Including this concept in the research gives a more complete picture that is useful in determining the best local actions.



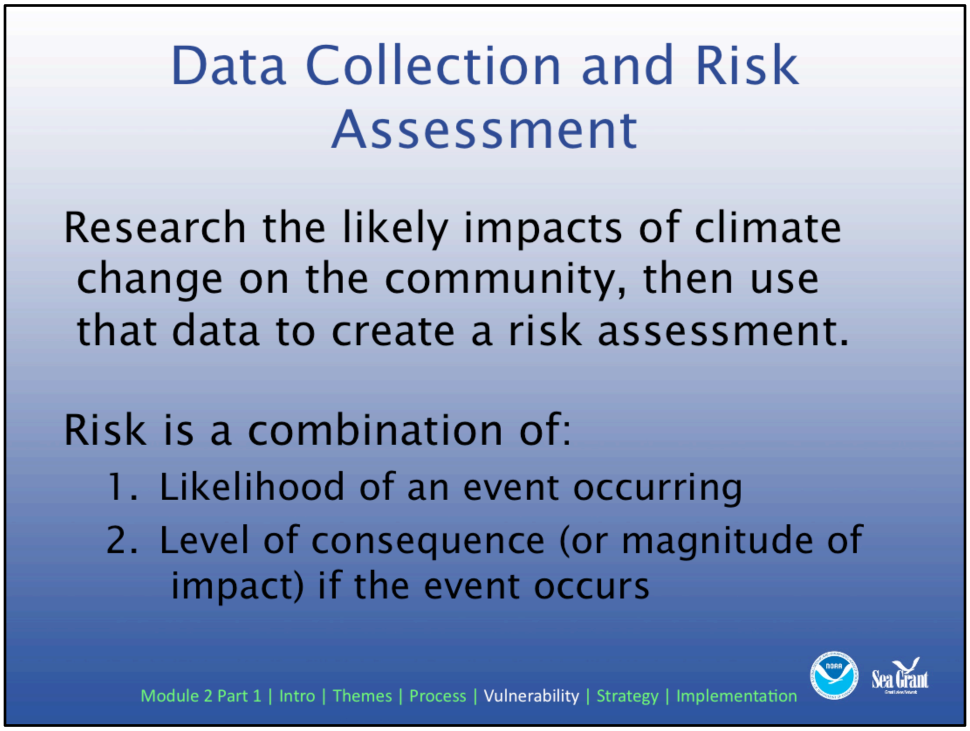
This graph shows the order of the Assessment process.
The planning team starts with information on predicted climate change, examines how that will affect the local community, and then selects working groups to pursue information about what risks and opportunities are likely. The research reports from the working groups will provide the basis for developing an appropriate adaptation plan.



Working groups go through 5 steps in assessing the local situation.

1. Identify the predicted climate change impacts and consider what consequences these will have for the specific community.
2. "Physical characteristics" are features and processes of the natural environment like elevation, hydrology, soil characteristics and land use, which determine things like water runoff patterns, health of wetlands, and number of buildings frequently flooded. "Exposure" refers to the assets (people, property, systems, and functions) that may be lost or damaged. Assess these by creating an inventory of population, infrastructure, natural resources, cultural resources, historical resources, and economic resources in a community.
3. Assessing adaptive capacity means considering how well systems can adjust to moderate potential damages from climate change. In the current context, that means assessing the ability of a government and population to prepare for, respond to, and recover from climate change impacts. Once the planning team has evaluated what elements of the local physical and social environment may affect the community's vulnerability to climate change, they can move on to step 4.
4. Scenarios are important tools for helping people think about options. Scenarios can be used to compare different severities of climate change (low/medium/high change) and how different combinations of options for adaptation would work for each level of severity. Mapping and visualization tools are helpful in developing scenarios. (See Module 3 for more information about tools)
5. Once the vulnerabilities are known, it is possible to create a summary that will be used to determine where to focus the adaptation efforts. This will be the basis for the adaptation goals and strategies to meet those goals.

From NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers*.



To create a Risk/vulnerability Assessment, researchers collect information about how a climate change impact will affect the community.

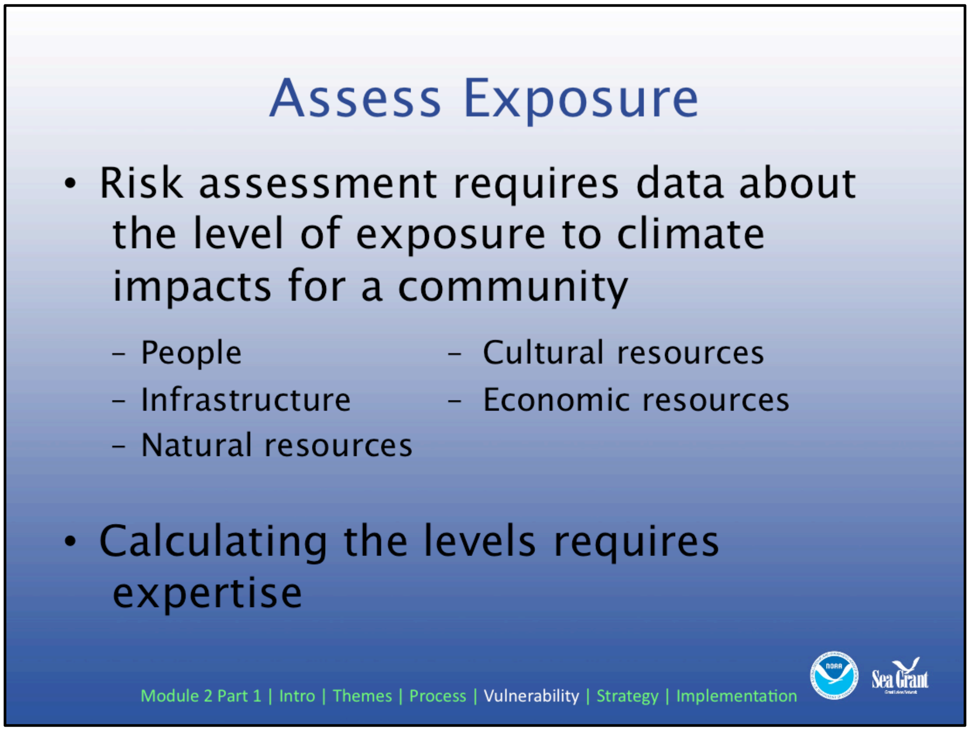
The size of the risk is determined by:

1) the likelihood of an event occurring and

2) the consequences to the community if it occurs.

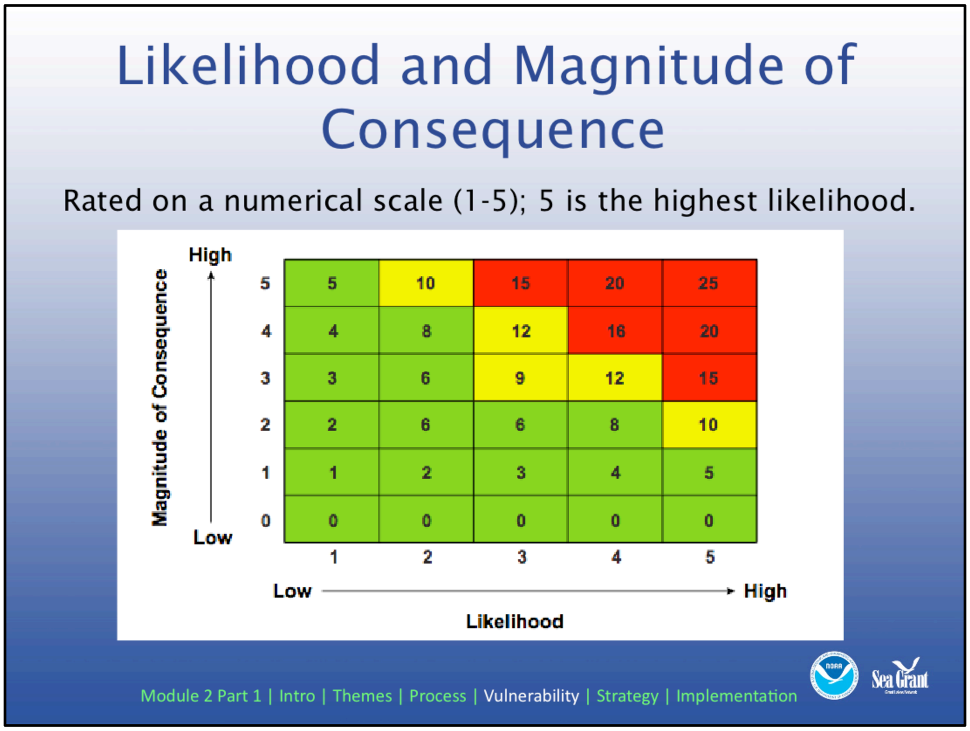
Examples of the level of consequence include number of deaths, infrastructure damage, and business disruptions.

This sample of a way to quantify risk comes from the *Chicago Climate Action Plan*.



The data that the working groups collect will provide this assessment.

Module 3 describes tools and resources to help calculate the levels of exposure.



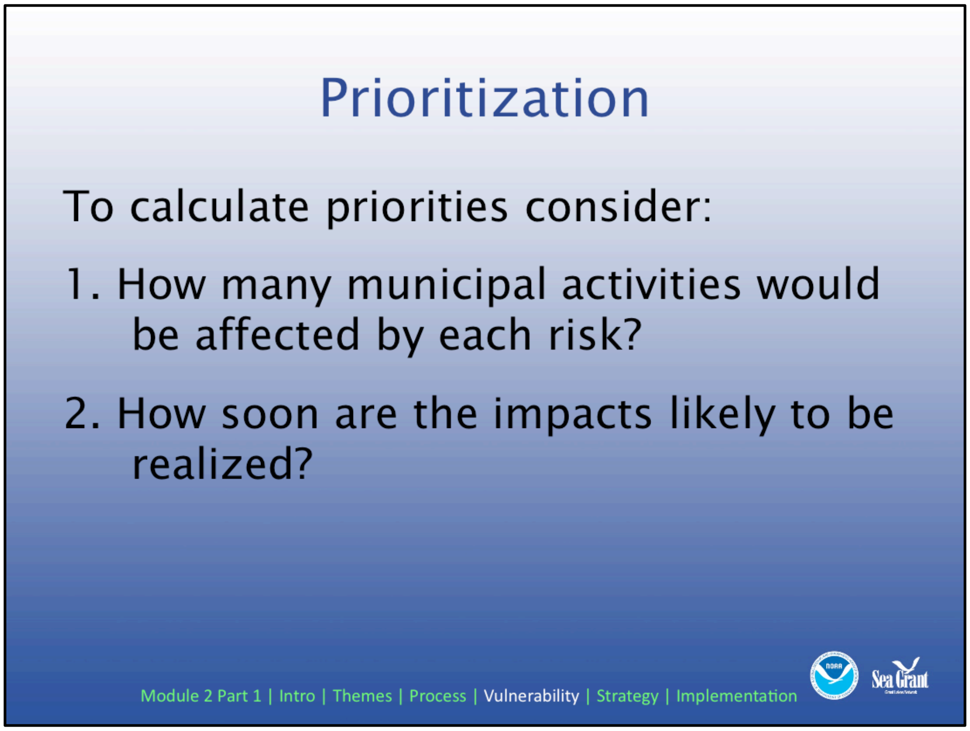
This chart is an example of a way to visualize a risk assessment. It was used in Chicago's Climate Change planning. Impacts that received high numbers for likelihood of occurrence and magnitude end up in the red zone.

Likelihood scale:
- 1 = unlikely
- 2 = somewhat likely
- 3 = likely
- 4 = very likely
- 5 = occurring now

Consequence scale (infrastructure costs):
- 0 = benefit (no cost)
- 1 = low cost
- 2 = moderate cost
- 3 = high cost
- 4 = very high cost (significant health effects and high costs)
- 5 = catastrophic cost (major loss of life)

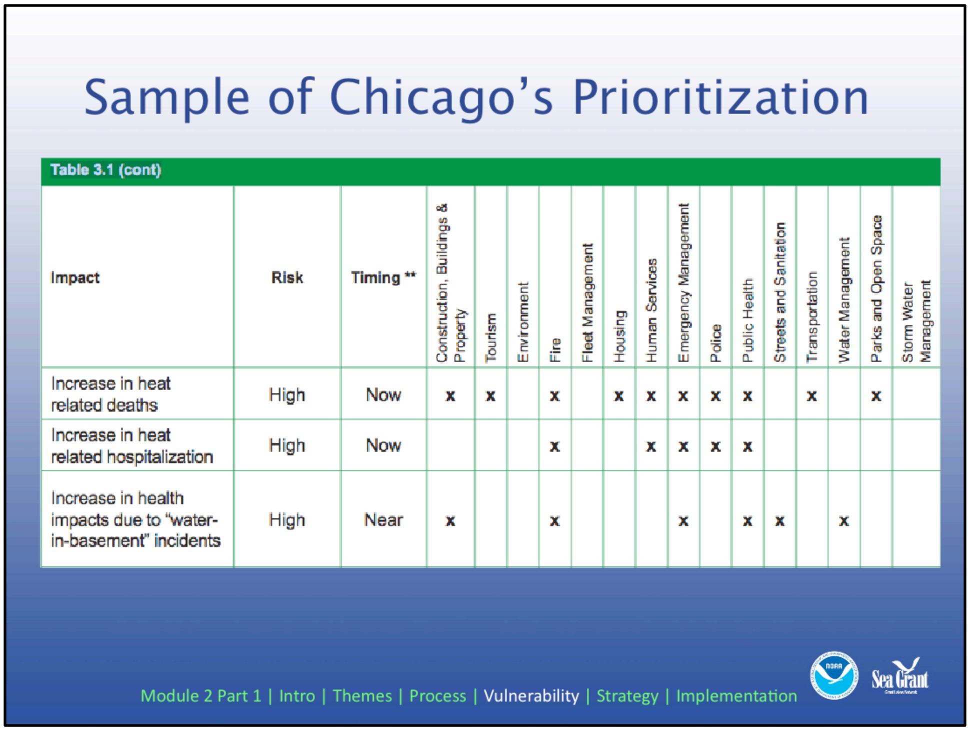
The use of 0 on the consequence scale to indicate beneficial impacts did not prove useful. Other communities might want to create a separate measure for benefits/opportunities related to climate change impacts. Knowing about these might affect the way a community allocates some resources. For example, rebates or low-interest loans could be targeted to offset irrigation equipment so that farmers can take advantage of a longer—but drier—growing season.

Chart from *Chicago Quick Guide to Climate Change Preparation,* June 2008



1. Examples of municipal activities/services include construction, street maintenance, public safety, public health, tourism, business, and schools. Knowing what activities will be affected can help determine how widely the impacts will be felt in the community, what agencies may need to be brought into the planning process, and where adaptation resources may be available.
2. When considering the timeline for impacts, think about now, 10 years from now, 30 years from now, and 50 years from now.

Knowing the level of the risk, the extent of its impact on a municipality, and the immediacy of the threat, the planning team can set priorities for allocation of resources. It is important to retain some flexibility in this prioritization. As the community explores adaptation options, discovery of opportunities to address impacts that are lower on the priority list may appear. For instance, these could be tied to current development or government grants that will expire shortly. Cases like these will have to be evaluated on an *ad hoc* basis.

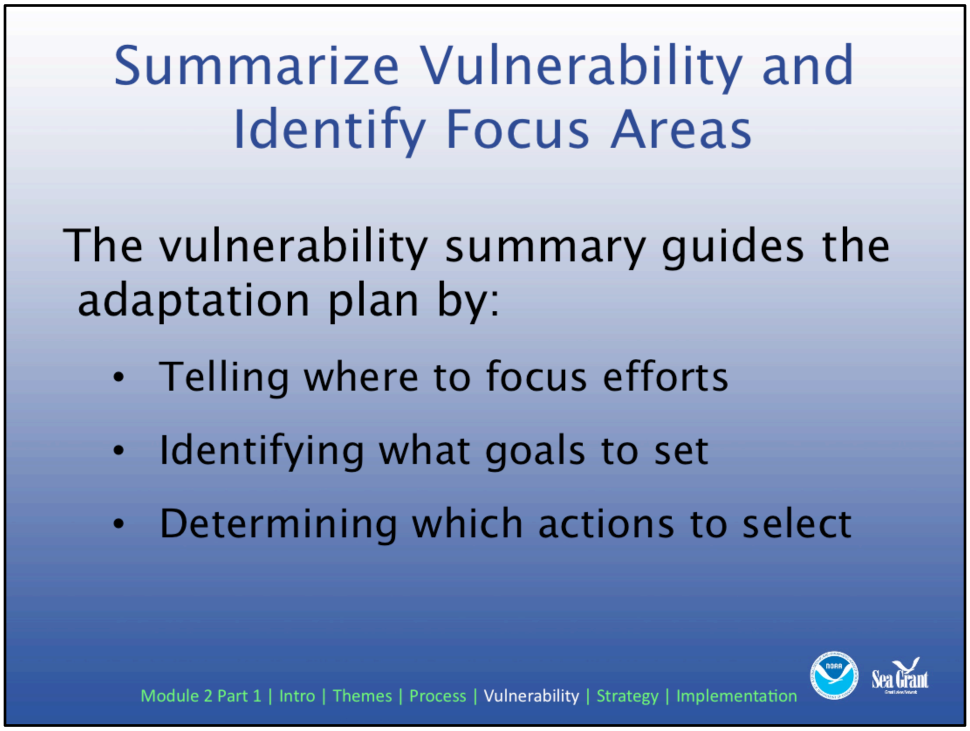


Impact	Risk	Timing **	Construction, Buildings & Property	Tourism	Environment	Fire	Fleet Management	Housing	Human Services	Emergency Management	Police	Public Health	Streets and Sanitation	Transportation	Water Management	Parks and Open Space	Storm Water Management
Increase in heat related deaths	High	Now	x	x		x		x	x	x	x	x		x		x	
Increase in heat related hospitalization	High	Now				x			x	x	x	x					
Increase in health impacts due to "water-in-basement" incidents	High	Near	x			x				x		x	x		x		

** Timing categories: Now = 2010, Near = 2010-2039, and Mid = 2040-2069.

Notice how many categories of municipal activity are being affected by the impact of increased heat versus "water-in-basement." These differences can help determine which issues are most urgent or where there are multiple agencies that may be enlisted in working toward a solution.

Image from *Chicago Quick Guide to Climate Change Preparation,* June 2008

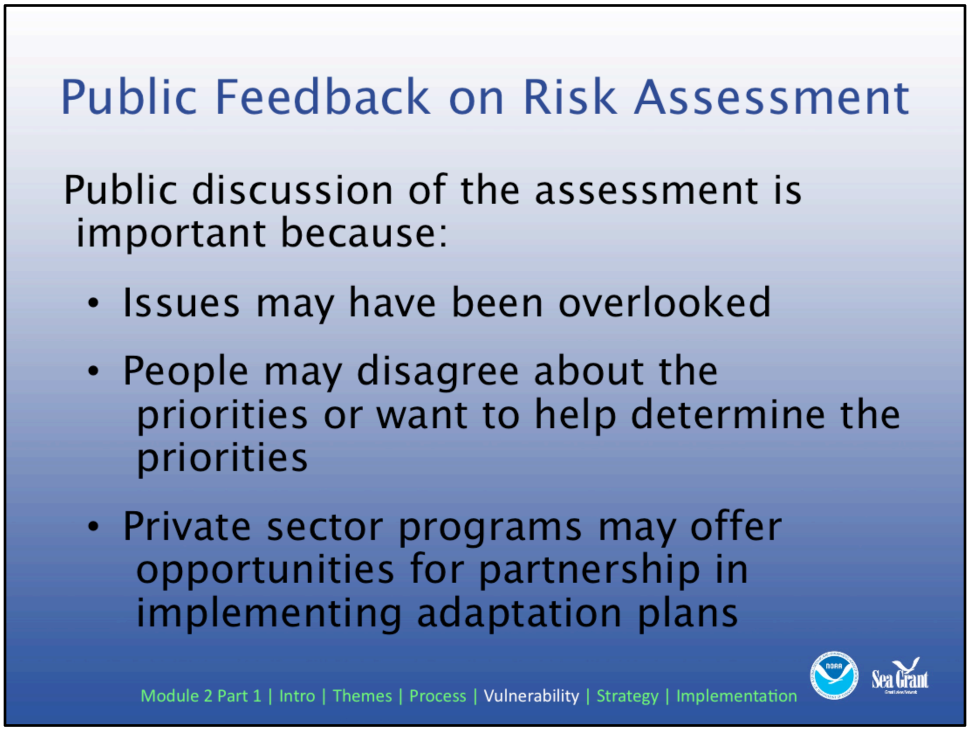


The gathered data is combined into a summary of vulnerability that ranks issues according to the magnitude of their impact on the community and how soon the impacts will be felt. This summary will guide the development of the adaptation plan. The summary identifies what impacts need to be mitigated soonest in order to reduce the costs of climate change; how to do this most effectively will be the subject of the actual adaptation plan.

Questions to help prioritize focus areas:

- What locations along the coast are most vulnerable to climate change impacts?
- What environments (natural, built) are most vulnerable to climate change impacts?
- What assets are most important to your state's coastal values, identity, culture, and economy?
- Which climate change impacts are likely to inflict the greatest losses (economically, socially, environmentally, etc)?

From NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*



Successful adaptation requires community-wide planning; it is vital to bring all parties together to share information and ideas so that widespread implementation will be possible. Once there is a summary report on the risks climate change poses for an area, this report can be presented to the wider community.

- This can help make sure that no community concerns were overlooked.
- If people have a chance to take part in the process and feel that the resulting priorities are valid, they will be more likely to support the adaptation plans.
- There may be small-scale programs within the private sector that offer opportunity for partnership in implementing adaptation plans.

Step 3: Create an adaptation strategy.
Now that the planning team knows what the local impacts of climate change are likely to be, and how these will affect the community, they are ready to consider strategies for adapting to those impacts and reducing their vulnerability.

This adaptation planning process is from NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*

The Adaptation Strategy also has 4 steps. **Note: Participants can use the *Planning Process: Developing the Adaptation Strategy* handout to follow along with this slide.**

1. Set formal goals that address the areas that will be affected by climate change. (See the accompanying handout for samples.) Reviewing plans from other communities can be helpful goal setting, even if they are not adaptation plans. (Useful plans may include topics such as hazard mitigation, emergency operations, environmental preservation, economic development, resource management, and transportation.) Involve stakeholders in the goal setting: this keeps them engaged and increases support for implementing the plan.

2. Once the team has (a) determined community climate impacts and (b) prioritized those issues, then working groups can be designated to research available solutions that will be incorporated into the adaptation plan.

   Resource limitations are a significant challenge for adaptation planning. Governments are already juggling multiple issues and have to meet current obligations, so finding resources for new projects is not easy. However, since climate change will exacerbate many existing management concerns, it needs to be included in current planning. Integrating climate concerns into current planning gives access to existing financial, technical, and institutional resources. An example of this can be seen in the case study about a countywide sustainability plan on the following slide.

3. The highest priorities have already been determined by the vulnerability assessment. These can be grouped if they (a) result from similar climate change impacts (such as effects caused by heavier precipitation) or (b) relate to the same municipal departments (for example, water management may be related to both flood and drought).

4. Brainstorm a wide array of strategies, then sort them for best options.
   - Consider where they overlap so agencies might be able to combine resources.
   - Look for "win-wins" that deal with multiple impacts or may add value to the community in the process of reducing climate impacts (like increasing green space or redeveloping brownfields in floodplains).
   - Choose strategies that build off of existing municipal programs and initiatives if at all possible. Strategies that do not fit into the municipality's programs will be difficult to implement—there will be no resources available and they will be in competition with existing programs.

The best mix of actions will depend on local needs and local resources. A cost-benefit analysis helps determine the most effective use of limited resources. Giving priority to lower cost options that can be accomplished quickly can help build momentum by showing the community that progress is being made.

One of the biggest challenges for Adaptation Planning is the shortage of resources for creating a plan. One solution is to integrate Adaptation Planning into existing planning structures that already have designated resources.

This example concerns Marin County's sustainability plan, but the creative solutions can be transferred to adaptation planning.

By making sustainability a theme of Marin County's regularly scheduled countywide plan, there were already budget and staff allocations. The county was able to utilize additional funding from outside sources that connected to issues covered by the sustainability plan.

Supplemental funds came from:
- Grants related to energy efficiency and hazard preparation.
- State funds available for planning how to fulfill state mandates at the county level.
- Fees for some building permits and land use.

Connecting to an existing planning process allowed for the use of existing staff. Note that two part-time workers can be assigned to manage a planning process if it is not possible to have one person be full time, and that paid and unpaid interns can also be useful.

For additional resources, consider partnering with universities and local businesses, which may have stakes in the outcomes of the planning process and be willing to donate labor, knowledge, and tools.

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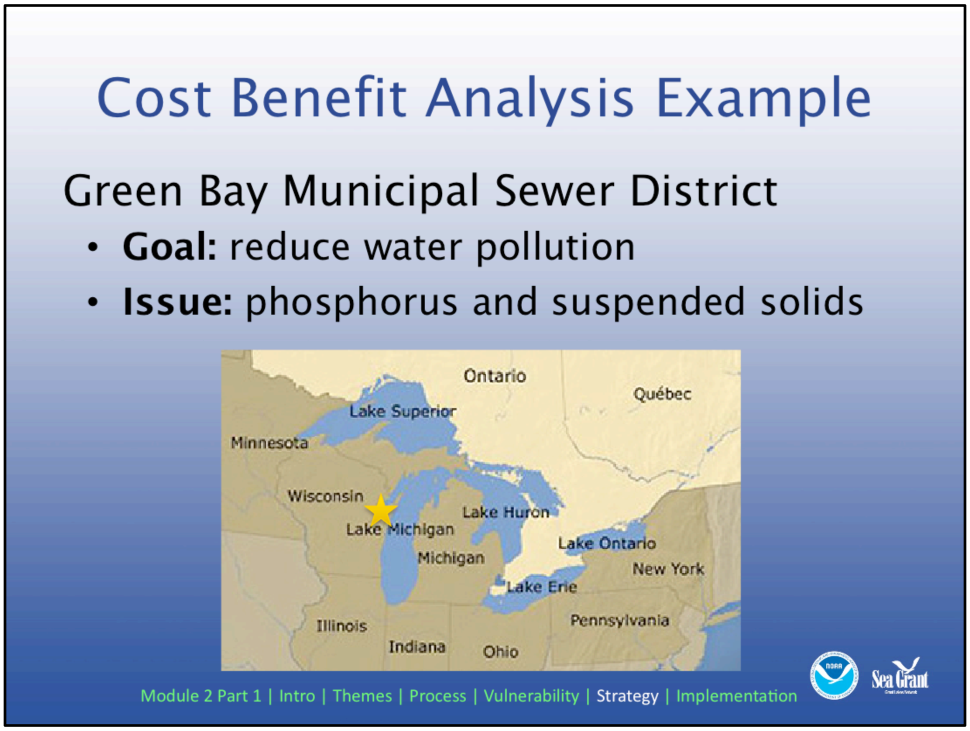
There is a longer description of this case study in the M2 supplemental materials.
Case study is described in Planning for a New Climate and Energy Future (American Planning Association, 2010)

Smaller communities face a lack of resources for doing climate research, but they can make use of resources from big cities and government sources.

Valuable resources can be found in the research reports from the Chicago Climate Action Plan and the Wisconsin Initiative on Climate Change Impacts (WICCI). These are the most advanced and thorough climate adaptation plans in the Great Lakes region at this time. Most of the reports that informed Chicago's climate plans are already on the city's website. The reports from WICCI are just being completed and placed on the website so some topics may not yet be available.

Resources are also available from NOAA, FEMA, EPA, and The Nature Conservancy.



Often, there are several strategies available for addressing an impact. The planning team can use cost-benefit analysis as one method for deciding which option is best. One example of how costs might determine the best course of action comes from Green Bay, WI.

The Green Bay Municipal Sewer District did an analysis of the sources of phosphorus and suspended solids, two major pollutants in the river water that were affecting the city and the bay. A research company developed a computer model to determine the sources of the pollution and analyze the most cost-effective locations for pollution reduction. The phosphorous and suspended solids came from agricultural regions upstream in the Fox River watershed and accumulated as they flowed downstream to Green Bay.

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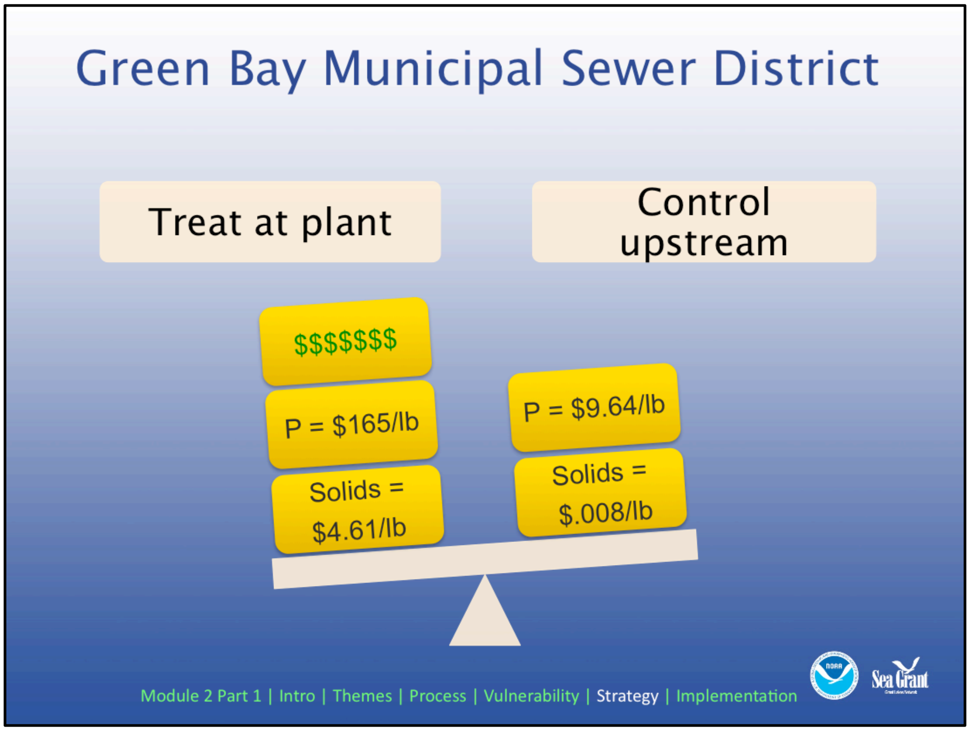
A longer description of this case is included in the M2 supplemental materials.

White, David, Paul Baumgart, and Bruce Johnson, eds. 1995. “Toward a Cost-Effective Approach to Water Resource Management in the Fox-Wolf River Basin: A First Cut Analysis.” Green Bay: Northeast Wisconsin Water of Tomorrow.



Economic analysis of control options:

- Reduce phosphorus in municipal water through technology at treatment plant = $165/lb
- Control phosphorus releases upstream = $9.64/lb
- Remove suspended solids at treatment plant = $4.61/lb
- Prevent suspended solids entering stream at outlet to watershed= $.008/lb

The most cost-effective option was determined to be controlling the pollutants upstream rather than treating them at a plant downstream. Low-cost reductions could be achieved through planting vegetative buffers along river banks to minimize erosion, encouraging more efficient use of fertilizers and pesticides, setting up zoning and livestock exclusion ordinances to minimize animal access to streams, and improving management of animal wastes.

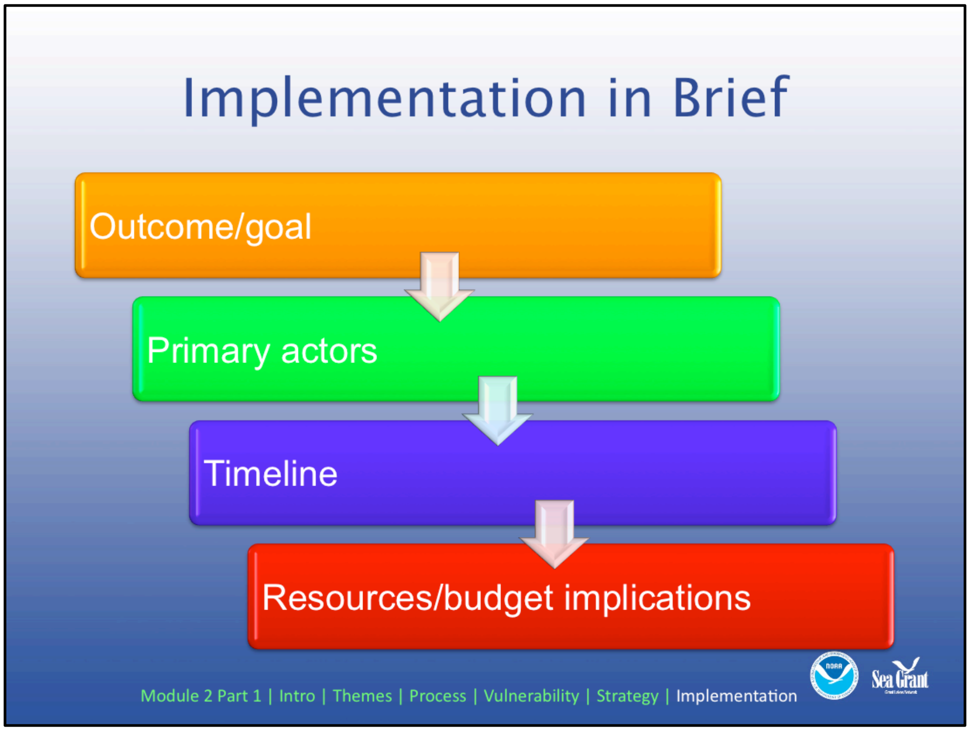
The state's Department of Natural Resources has pursued these goals by hosting educational outreach programs directed at changing farming practices, providing technical assistance, and partially subsidizing the costs of new, non-point source controls. The major weakness of such a source-reduction process is that changing human behavior can be slow, whereas installing technology has a clearly defined timeframe.

There are lots of context-specific details that affect a cost-benefit analysis, so these numbers will not be the same for other communities. But the study shows that such analyses are possible.

White, David, Paul Baumgart, and Bruce Johnson, eds. 1995. "Toward a Cost-Effective Approach to Water Resource Management in the Fox-Wolf River Basin: A First Cut Analysis." Green Bay: Northeast Wisconsin Water of Tomorrow.

Step 4: Once a community has determined what adaptation actions are most appropriate for its local needs and resources, it is time to design a process for implementing the action plan.

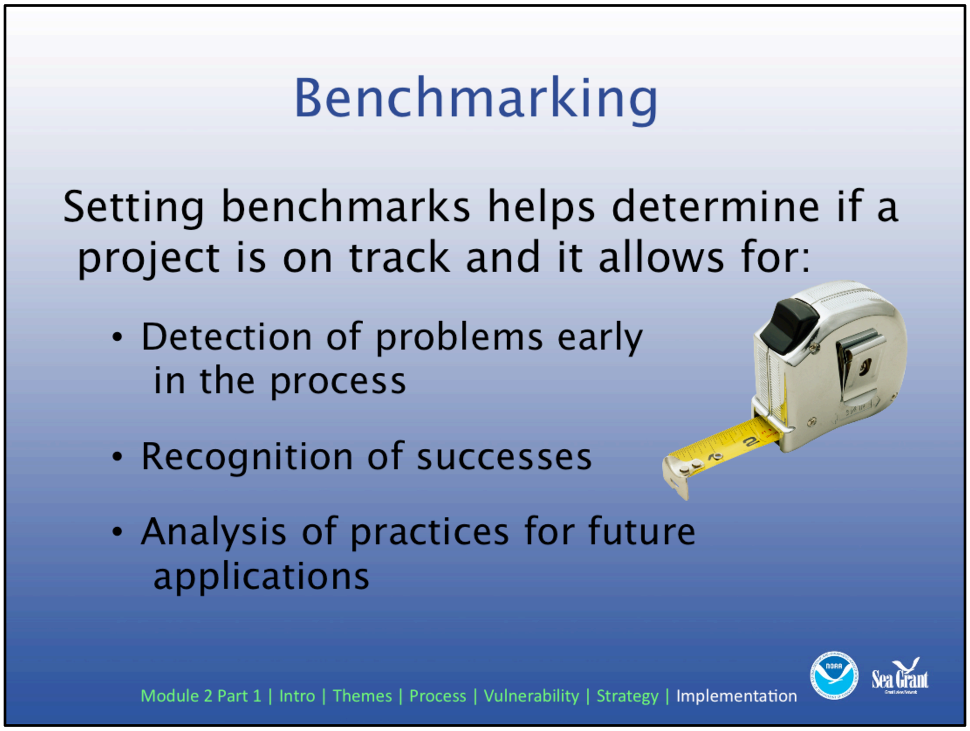
From NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*



An implementation plan describes what the goals are, who has responsibility for achieving which goals, timing and benchmarks for achieving the goals, and what resources are going to be used to accomplish the goals.

These can be determined by asking the following questions:

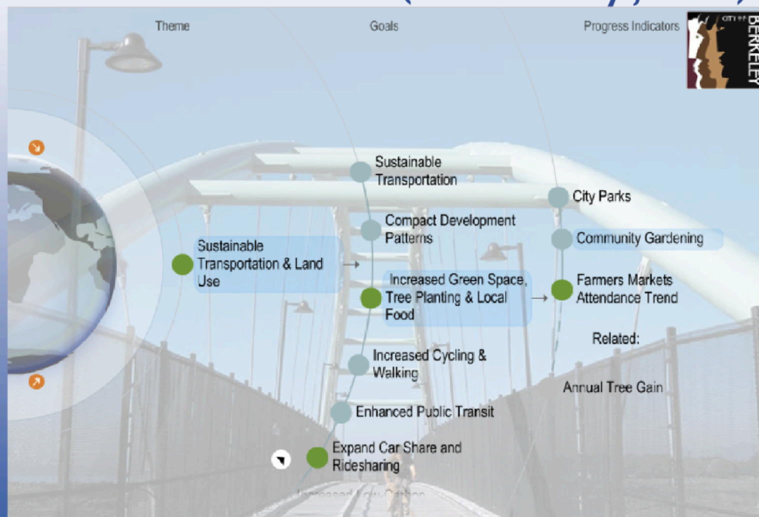
- What is the desired outcome?
- Who (agencies, departments, organizations, etc.) is responsible for achieving that outcome?
- How will results be achieved? For example, changes to regulations, retrofitting structures, or zoning. Examples of strategies for achieving results will be included in Part 2 of this presentation.
- What resources (e.g., funds, staff, events, and materials) will be used to achieve the result?
- How will success be measured? For example, number of trees planted or buildings insulated, completion of a drought plan or updating of flood maps.
- How will evaluation of progress be made accessible? For example, website, published reports, and public meetings.



Trying to determine why something is working well (or not) can be useful for improving efforts in other areas. Evaluating whether a program is meeting its benchmarks also helps determine if the strategy is cost-effective and if more resources are needed for successful implementation.

Continuous assessment is especially important for climate adaptation because of the uncertainties in the long-range predictions. As information improves and new data develops, plans will need to be updated. Benchmarks can set specific timelines for making these updates.

See-it Website (Berkeley, CA)



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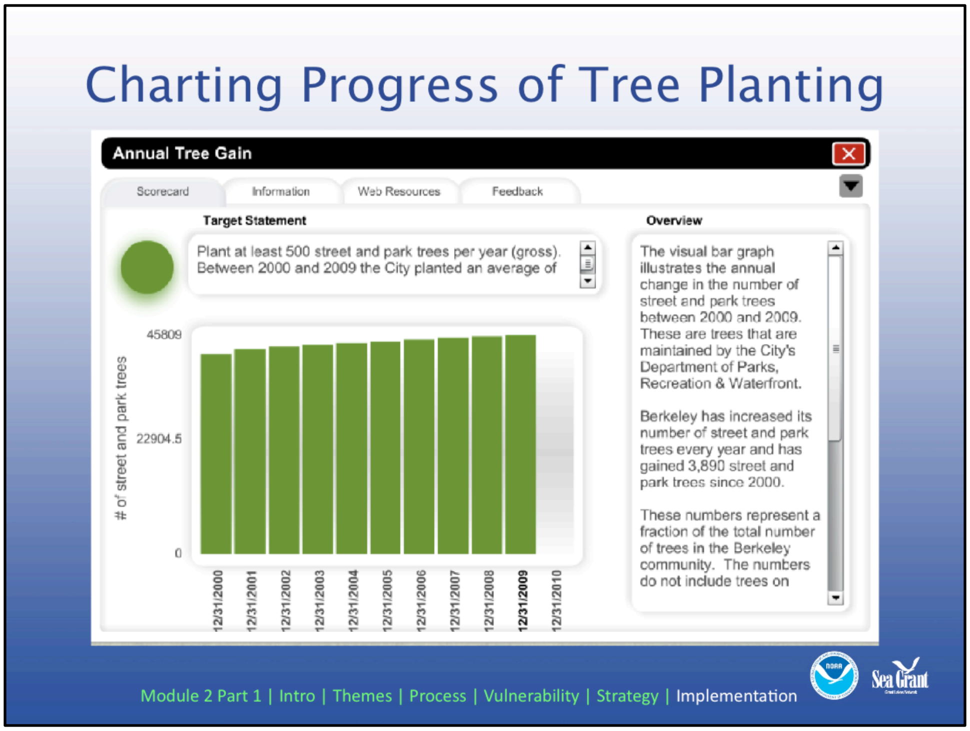
Here is an example of a system for keeping the public up to date on benchmarks. The City of Berkeley created a sustainability plan and developed a website called "See-it" to inform people about the plan.

The inner ring around the earth shows themes like transportation and land use, the middle ring shows the goals of the city plan, and the outer ring shows indicators of how well the city is doing in achieving the goals.

Clicking on a green dot takes you to a page that includes more data about the goals, actors, and current measures of progress. It will also explain whether the city is on track or not—and what variables are affecting this progress.

www.cityofberkeley.info/climate/



Here, for example, is the See-it page describing the city's progress toward its target goal of planting 500 new trees per year. The scorecard tab shows the city's progress: although the city has planted nearly 4,000 trees over 9 years, this is slightly below the target. Other tabs provide information about the goals and the reasons for wanting to increase the number of trees, web resources, and a method to provide feedback to the city planners.

Tree planting programs have proven particularly successful for cities. Citizens like trees and it is easy to show that benchmarks are being met since there is clearly visible evidence of progress.

Benchmark pages can also explain why a goal is not being met. For example, Berkeley has a target for reducing greenhouse gas emissions from utilities; however, a drought caused a reduction in hydropower and an increase in coal-based electricity use, so the city is not on track to meet that target.

www.cityofberkeley.info/climate/

Climate adaptation plans require regular re-evaluation and updating. This is true for all municipal plans, but it is especially important with climate change. The exact impacts of climate change involve many uncertainties, so the plans need to be flexible; new science and technologies may change recommendations for best practices. Building regular assessment and adjustment into the plan from the beginning will make it easier to update the plans.

Even though many communities may not be able to implement a full range of adaptation strategies immediately, it is still worthwhile to create a comprehensive plan. The community can set priorities and begin with some of the simpler measures—or target a specific area for early adoption and phase in other measures as resources allow.

Resource limitations are quite real. Communities will have to decide that adaptation is going to pay off before there will be support for it. One idea that may help is to remember that federal (and state) government funding is growing in this area. If a community develops a plan now, then they will be ready to take advantage of funds as they become available and will be in a better position to compete for these new resources.

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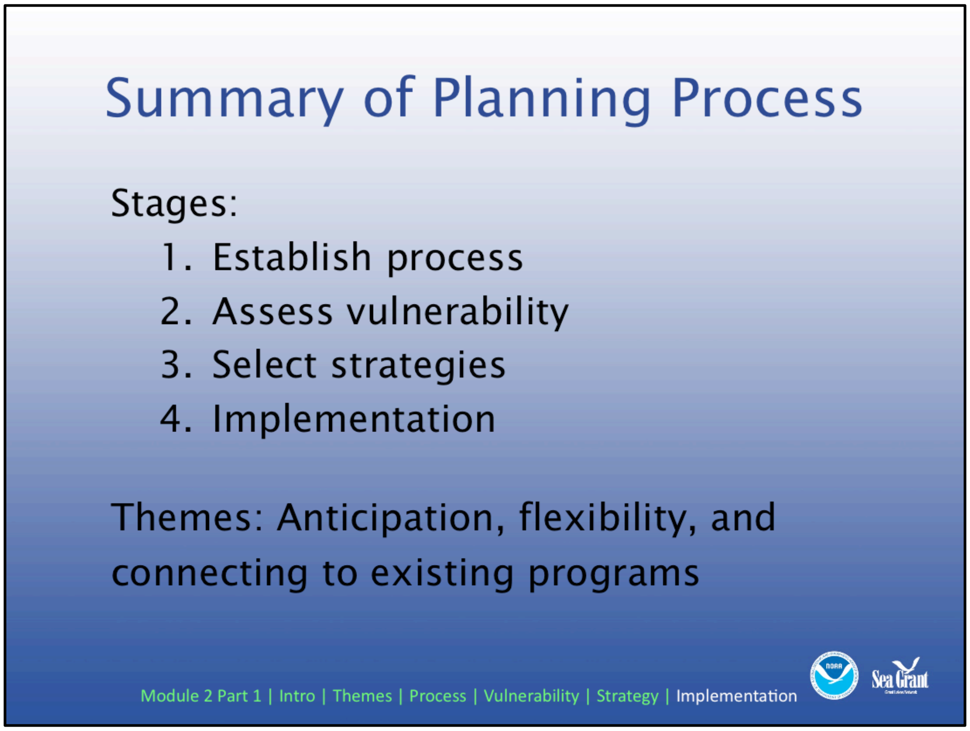
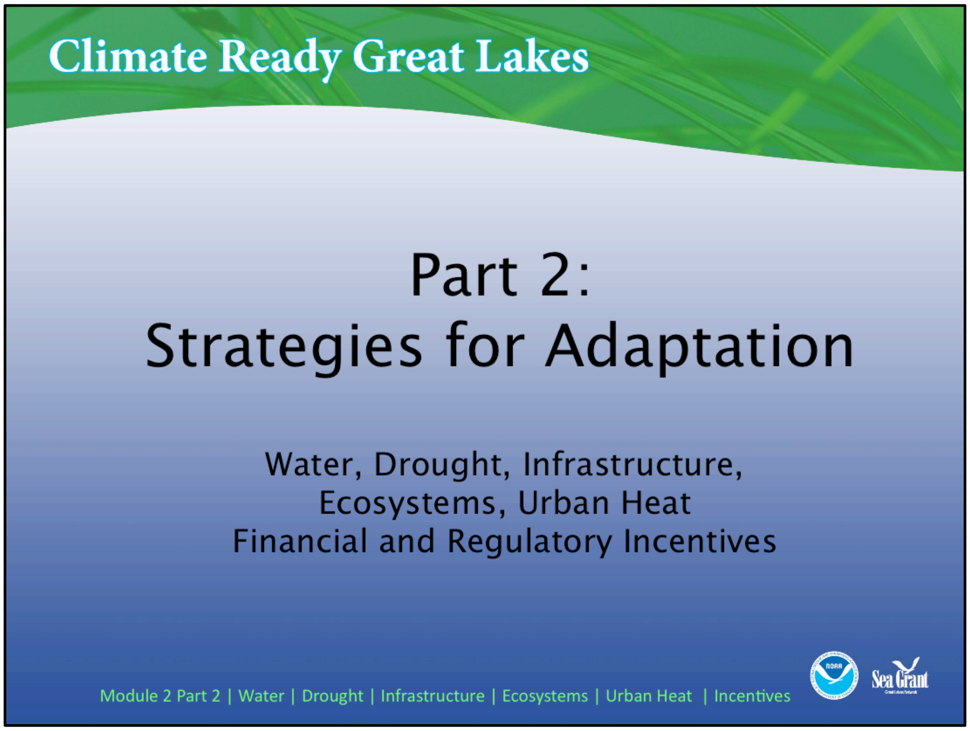
Center for Science in the Earth System (The Climate Impacts Group); Joint Institute for the Study of the Atmosphere and Ocean; ICLEI – Local Governments for Sustainability. *Preparing for Climate Change: A Guidebook for Local Regional, and State Governments.* pp 28-31.



Summarize the first part.

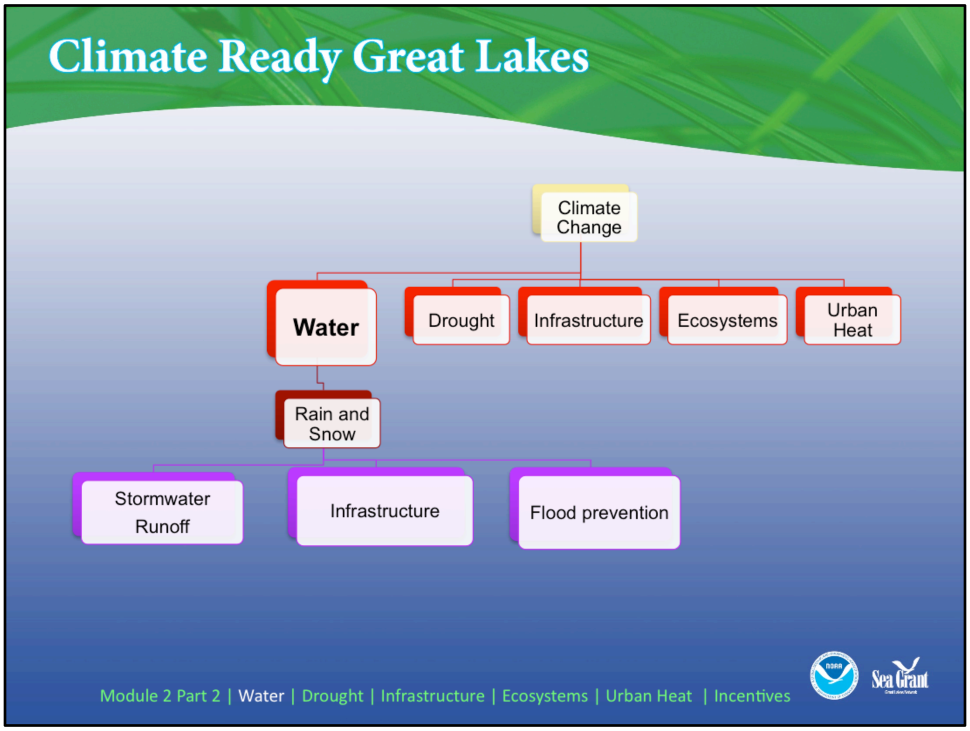
Then hand out Worksheet 1 and ask people to take time to fill it out. This can be followed by discussion of the worksheet in small groups or with everyone together. The worksheet is designed to help people start thinking about how the predicted climate impacts will affect their own community and what aspects of the community will be most affected—it is a miniature Vulnerability Assessment. The worksheet should also prompt workshop participants to see how the climate change will affect multiple aspects of the community so there is overlap among the services and departments responsible to dealing with the results. This will encourage them to think about the importance of collaboration across departmental boundaries and the potential for shared resources.



Now that we know how to develop a plan, Part 2 will describe some strategies that could be incorporated into the plan in order to address specific climate change impacts. These are the “options” that would be considered in Step 3 of the Planning Process (Select strategies).

The strategies will be organized according to the following topics: water management, drought, infrastructure, ecosystems, and urban heat.
All of these will be affected by climate change.

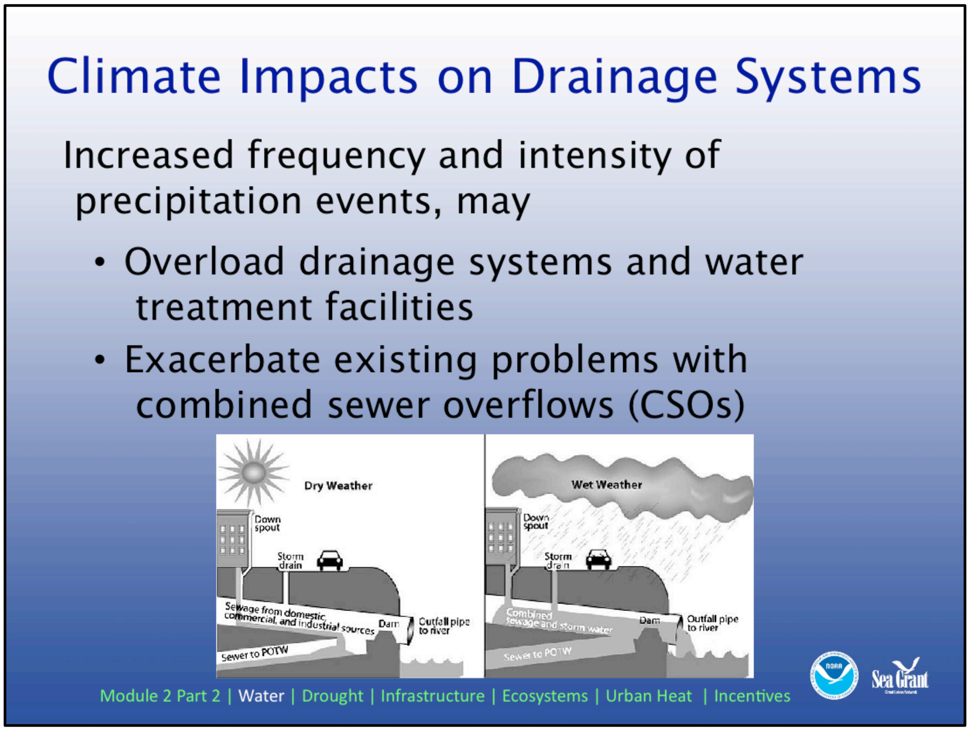
A final section will describe financial and regulatory incentives that may encourage people to implement climate adaptation plans.



Water management is an area where climate change will have significant affects on communities.

Climate change will increase the number of extreme weather events. Rain and melting snow increase runoff and affect infrastructure, health, and ecosystems. Management strategies aim to prevent harm to life and property.

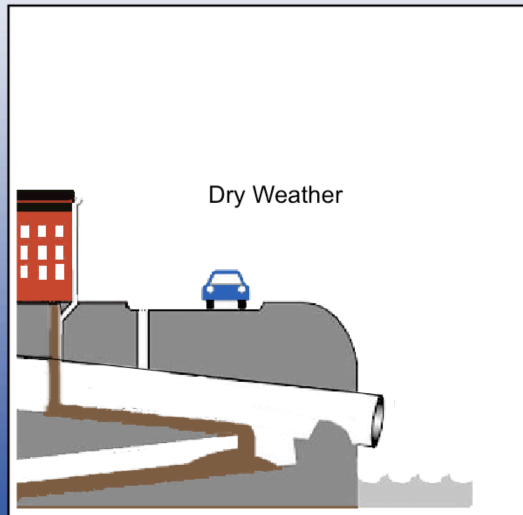
This module will describe some strategies related to stormwater runoff, infrastructure, and flood prevention.



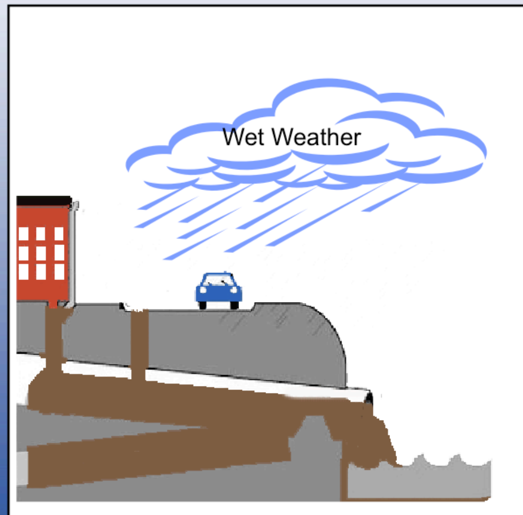
The frequency of heavy rain events will increase with climate change, which can pose problems for communities with combined sewer overflow systems (CSOs). In CSOs, the same pipes collect rainwater runoff, sewage, and industrial water. Normally, the CSO can handle the whole load and direct it all for treatment. However, during heavy storms, the wastewater treatment plants can't handle the increased volume of water, and the systems overflow into local rivers and lakes. Of the 801 cities in the United States with active combined sewage systems, 65% are in Great Lakes states.

Figure credit: EPA

Combined Sewer Overflows



Combined Sewer Overflows



Effects of CSOs

- Poor water quality
- Beach closures
- Risks to human health

When over a billion gallons of sewage is released into our rivers and lakes from CSOs during heavy rains, water quality diminishes and beaches are closed. CSOs can also negatively affect human health, since waterborne diseases in drinking water can be more prevalent after heavy storm events. For example, in 1993, an outbreak of a parasitic disease (called *Cryptosporidium*) occurred in Milwaukee right after a large storm, causing 400,000 people to fall ill with diarrhea.

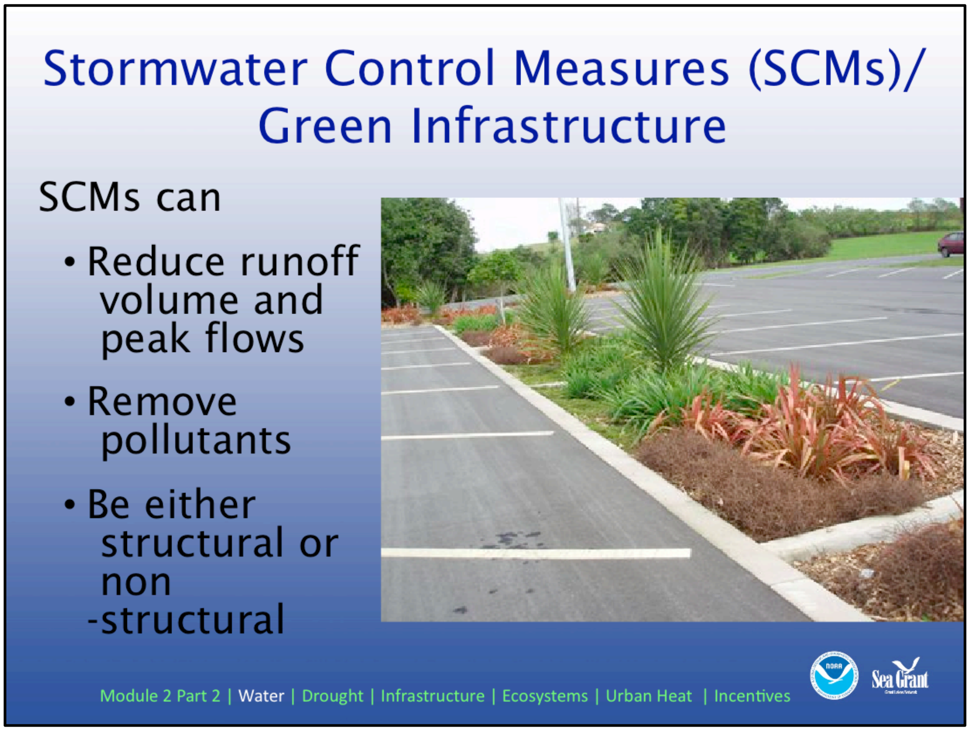
One of the most effective ways to address the CSO problem is for a city to undertake a sewer separation project—that is, build a second piping system for all (or part) of the community. However, high capital costs or physical limitations may preclude this as an option for most communities.

Another solution is to build a CSO storage facility (such as a tunnel) that can store flow from many sewer connections. Storage tunnels store combined sewage, but do not treat it. When the storm is over, the flows are pumped out of the tunnel and sent to a wastewater treatment plant.

Installing retention treatment basins is another option. These large, concrete tanks store and treat combined sewage by (1) sending the most polluted water (from the first part of a storm) to the wastewater treatment plant after the storm and (2) treating the later flows with bleach.

Screening and disinfection, or flow-through, facilities treat CSO without ever storing it. They use fine screens to remove solids and sanitary trash from the combined sewage, and inject disinfectant into the flows. All of the materials removed by the screens are then sent to a wastewater treatment plant.

Finally, one of the least expensive options for dealing with CSOs is to reduce the amount of stormwater runoff created in the first place by using stormwater control measures.



Stormwater Control Measures (also known as Green Infrastructure) attempt to mimic natural hydrology to manage stormwater runoff closer to its source. SMCs reduce runoff volume by allowing stormwater to infiltrate the ground or evaporate after a storm, instead of piping the water offsite. For example, in this photo, water from an impervious surface (the concrete parking lot) flows into a vegetated bioswale, where it is allowed to seep into the ground. This helps to both reduce peak flows and remove pollutants from rainwater. SCMs can be both structural (such as the bioswale) or non-structural.

Picture source:
http://www.landcareresearch.co.nz/research/built/liudd/casestudies/case_manukau.asp

Note: Participants can turn to the Stormwater Control Measures handout to follow along with the next 2 slides.

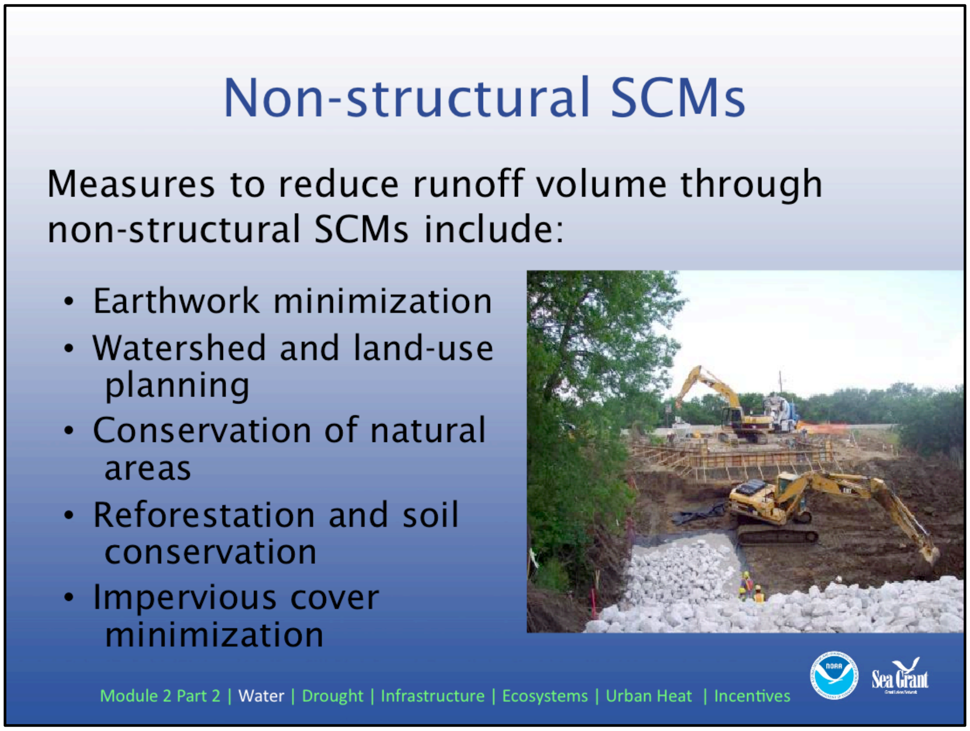
Structural/engineered SCMs help capture and retain stormwater near where it first falls. These SMCs serve multiple functions (such as preventing streambank erosion, flood control, and large-scale habitat provision).

Examples of structural SCMs include:

- **Bioswales**: a swaled drainage course with gently sloped sides, filled with vegetation, compost, and/or riprap. The swale is designed to remove silt and pollution from surface runoff water and allow water to drain.
- **Wet/dry ponds (also called detention basins)**: wet or dry areas sunk into the ground that are designed to collect runoff during rain events.
- **Stormwater wetlands**: wetlands constructed to absorb excess runoff from storm events.
- **Green roofs**: a roof that is partially or completely covered with vegetation (planted over a waterproofing membrane) that absorbs rainwater as it falls.
- **Pervious pavement**: a special type of concrete with a high porosity that allows water from precipitation events to pass through the pavement.

Source: National Research Council, *Urban Stormwater Management in the United States* (2009)

Picture source: http://www.lakecountyil.gov/Stormwater/LakeCountyWatersheds/BMPs/Bioswale.htm

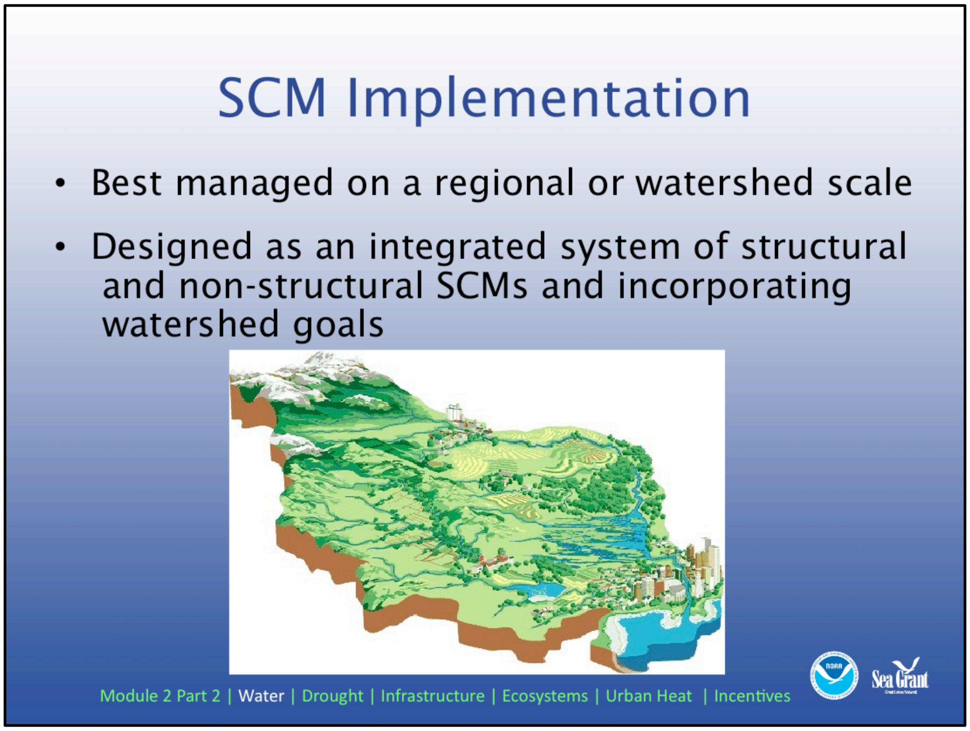


Another way of dealing with stormwater runoff is by using non-structural SCMs. Non-structural SCMs are generally longer-term and lower-maintenance solutions than structural SCMs, and can also greatly reduce the need for and/or increase the effectiveness of structural SCMs. Examples of nonstructural SCMs include:

- **Earthwork minimization**: limiting the degree of clearing and grading on a development site in order to prevent compaction, conserve soils, and prevent erosion from steep slopes.
- **Watershed and land-use planning**: making land-use decisions that change the location or quantity of impervious cover created by new development through zoning, watershed plans, comprehensive land-use plans, or Smart Growth.
- **Conservation of natural areas**: protecting natural features and environmental resources that help maintain the pre-development hydrology of a site by reducing runoff, promoting infiltration, and preventing soil erosion.
- **Reforestation and soil conservation**: improving the quality of native vegetation and soils present at a site by planting trees and plants, tilling, and amending compacted soils to improve their hydrologic properties.
- **Impervious cover minimization**: reducing the amount of impervious cover through practices such as reducing street, driveway, and parking lot areas; using permeable pavement; and installing swales and other bio-retention areas near impervious surfaces.

Source: National Research Council, *Urban Stormwater Management in the United States* (2009)

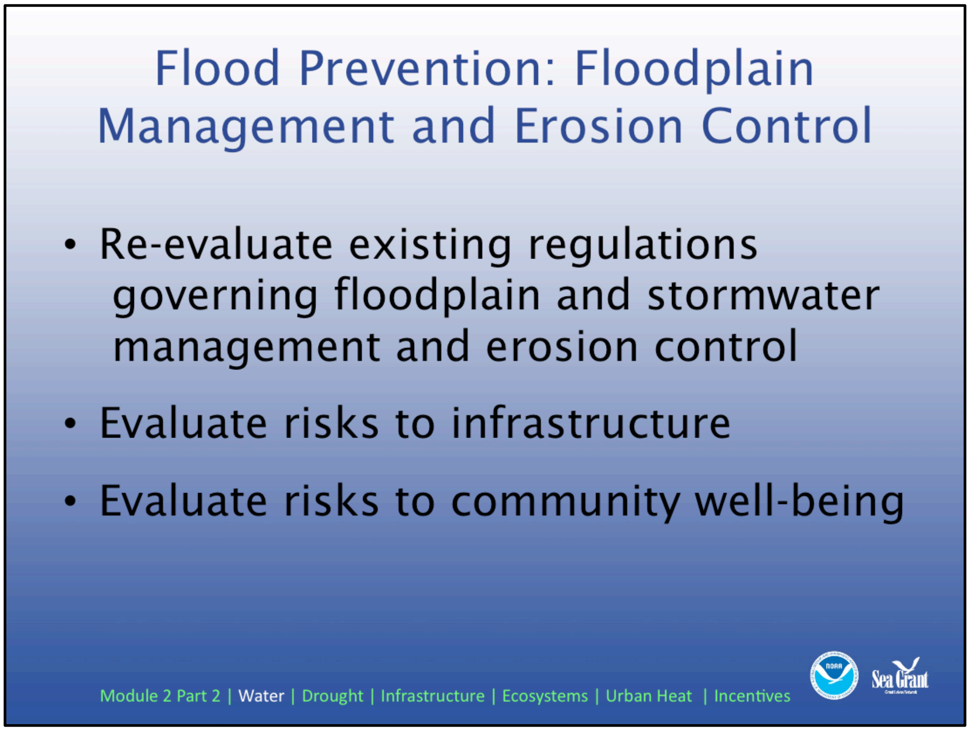
Photo source: http://www.mwvetcon.com/4.html



Stormwater is best managed on a regional or watershed basis (as opposed to relying solely on a site-by-site basis), due to the complexity of both the hydrologic and pollutant processes and their effect on habitat and stream quality. Therefore, SCM implementation is ideally designed as a system, integrating structural and non-structural SCMs and incorporating watershed goals, site characteristics, development land use, construction erosion and sediment controls, aesthetics, monitoring, and maintenance.

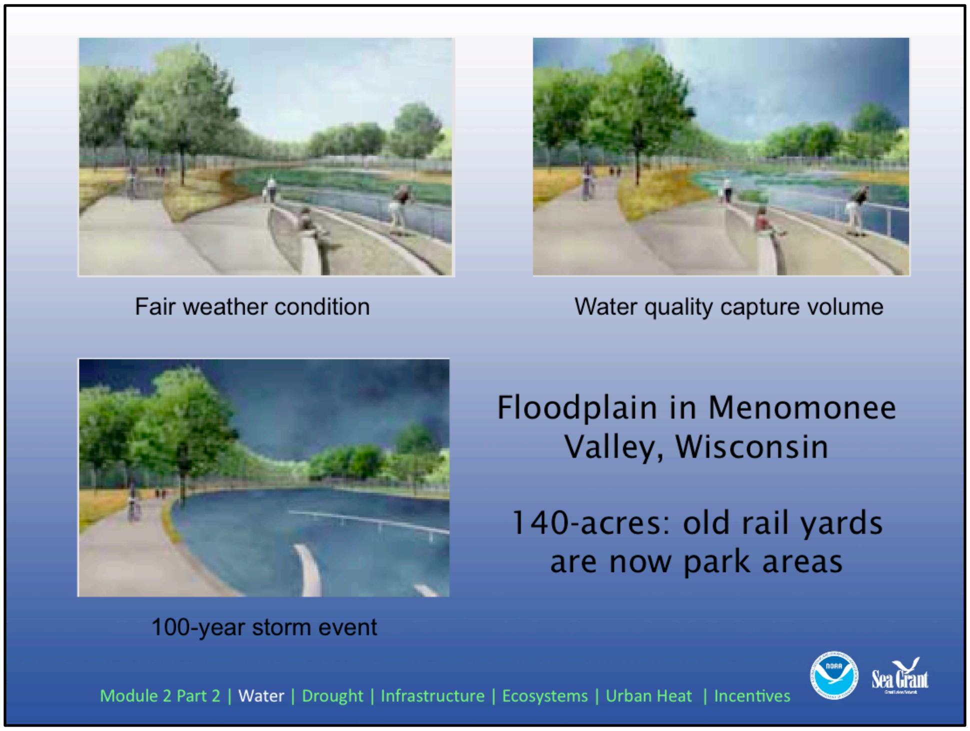
Source: National Research Council, *Urban Stormwater Management in the United States* (2009)

Picture source: http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1187635073613&lang=eng



Communities may need to

- Re-evaluate existing regulations governing floodplain and stormwater management and erosion control. For example, even recently updated Flood Insurance Rate Maps (FIRMs) are probably based on historically-derived assumptions and may not account for potential climate change impacts. FEMA has just issued new flood maps and these will help with efforts to update regulations.
- Evaluate risks to infrastructure (such as buildings, roads, public services, and energy).
- Evaluate risks to community well-being, such as health and water supplies. Often water supplies and waste-water treatment are located in flood-prone areas.



The Menomonee Valley Redevelopment Project is an example of planning ahead to reduce costs of climate change (in this case from more frequent heavy rain events) rather than waiting to react afterwards.

This 140-acre redevelopment of abandoned railyards illustrates how a Brownfield site within an existing floodplain can be redeveloped using both onsite and consolidated treatment. Consolidated treatment is incorporated into park areas, which provide recreation for adjacent neighborhoods and also serve as a centerpiece for a developing light industrial area that provides jobs to surrounding neighborhoods. The volume of water that, by regulation, must be captured and treated on individual sites is conveyed through a conventional subsurface system for treatment in park areas. This park area also prevents development in a floodplain and reduces the potential costs of damage during 100-year storm events.

Case described in: National Research Council, *Urban Stormwater Management in the United States* (2009)

Structural Flood Prevention

Traditional approach to flood prevention:

- Levees
- Drainage channels
- Combined sewer and storm drain

Carson River near Empire Ranch Golf Course during the New Year's 2006 flood.
Photo courtesy of the Reno Gazette-Journal.

Structural flood prevention is still important. However, regulations may need to be adjusted (such as larger pipe diameters or different configurations of drainage channels). These changes can be incorporated into regularly scheduled maintenance.

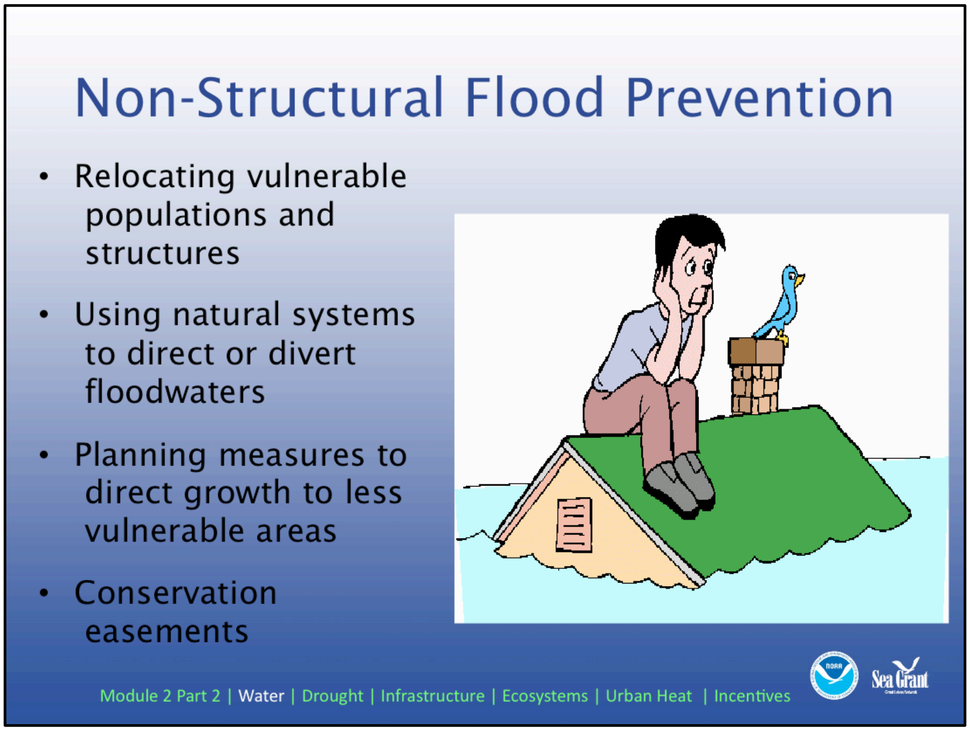
A good resource for information on structural flood prevention is the technical literature on wetlands management plans developed by the U.S. Army Corps of Engineers and others. There are a number of examples of Comprehensive Wetlands Management Plans (CWMPs) available online.

Picture source: nevada.usgs.gov

Non-structural flood prevention has gained popularity in regions that have experienced frequent flooding. Often there are FEMA funds that can help with relocation after a major event.

For example, flooding has been a frequent problem in Austin, Minnesota, on the banks of the Cedar River. In 1993, flooding damaged 450 homes and the city used buyouts to reduce the number of people in the floodplain. Funded under FEMA's Hazard Mitigation Grant Program and the Minnesota Department of Natural Resources, the acquisition project was administered through the Minnesota Division of Emergency Management. Some residents took advantage of an offer to help them move their homes to higher ground, but they faced the problem of finding vacant land for the houses. Fortunately, the Board of Education had just torn down an old elementary school, and the city purchased the land and gave flood victims preference in buying the lots. In 1994, five homes from a flooded area were then moved to the school land, which also had the added benefit of keeping neighbors together. (The picture shows the homes that were relocated to a higher elevation.)

FEMA. *The 1993 Great Midwest Flood: Voices 10 years later*



Climate change will increase heavy precipitation events and may cause flooding in areas that have not been at risk in the past. Doing an analysis of flood risks using the new FEMA flood maps can help prevent development in areas that may become vulnerable in the future. Anticipating and preventing damage is much easier than restoration afterwards.

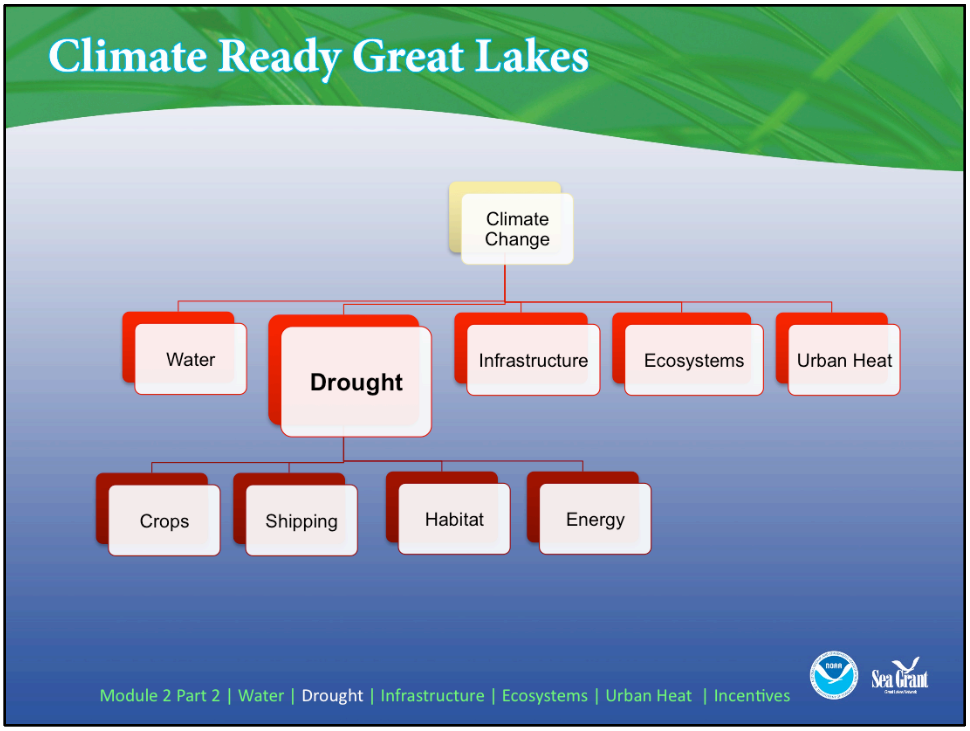
Setting aside flood-prone areas can have additional benefits. Often areas that are vulnerable to flooding, erosion, storm surge, and other climate change threats have scenic value that contributes positively to community character. Areas that are difficult to serve efficiently (rural, mountainous, or rocky) may also be scenic. Focusing conservation efforts in these areas can reduce risks to human populations while supporting quality of life, economic development, and infrastructure efficiencies. Such conservation can also create buffer zones to minimize climate change stresses on community resources.

Source: American Planning Assoication. *Planning for a New Climate and Energy Future*. pp 69.

Picture source: http://www.themoneyalert.com/WhentheWaterRisesArticle.html

Water Management Summary

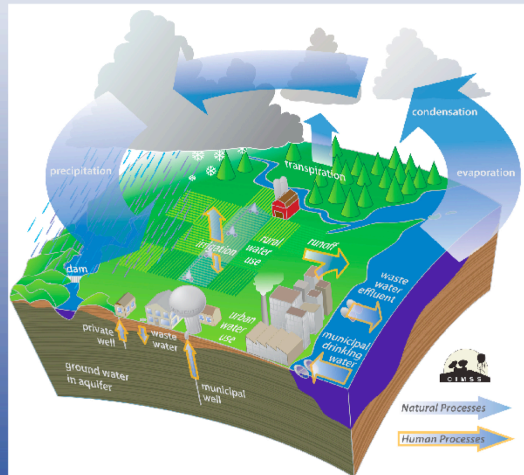
- Climate change → Increase in heavy precipitation events
- Green infrastructure (structural SCMs)
  - Manage water flow
  - Improve water quality
  - Reduce flood hazard
- Regulations and development



Droughts are a normal part of North American climate patterns. However, climate change is predicted to make them more frequent in the Great Lakes region. Droughts are a challenge for communities because they are:

- Unpredictable. Consider the 1998 drought, which occurred shortly after 1985's record high precipitation that led to historic high water levels on 4 of the 5 Great Lakes (11/85 – 10/86). The abrupt reversal caught people by surprise.
- Difficult to manage. Drought is a gradual phenomenon that has no defined beginning or end; droughts have varying severity and thus affect society differently.

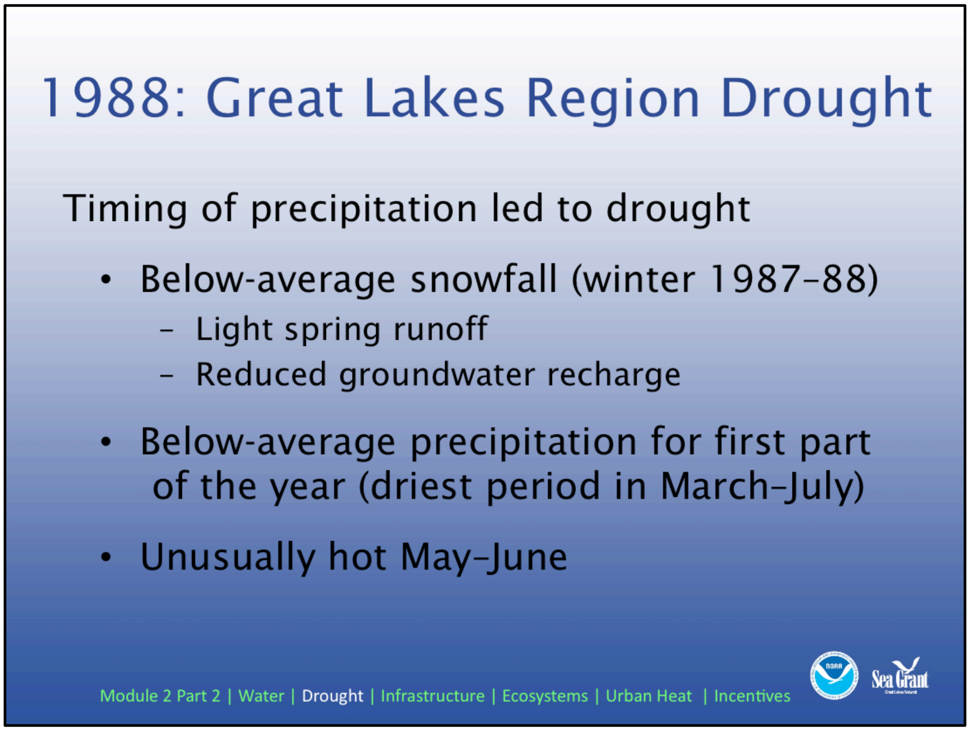
Drought: Lack of Precipitation Disrupts Hydrological Cycles



Module 2 Part 2 | Water | Drought | Infrastructure | Ecosystems | Urban Heat | Incentives

Hydrological cycles normally move water from lakes, oceans, and other bodies of water to the atmosphere by means of evaporation. Water also moves to the atmosphere out of soil and plants through evapotranspiration. Water is then returned to the earth through precipitation (rain and snow). Some of this water runs off into streams, rivers, lakes, and oceans—and some percolates through the soil into the groundwater system. Continuing precipitation shortages eventually lead to reduced groundwater levels, reduced streamflows, and lowered lake levels.

Great Lakes Commission. 1989. *Guide to Drought Planning, Management, and Water Level Changes in the Great Lakes*.

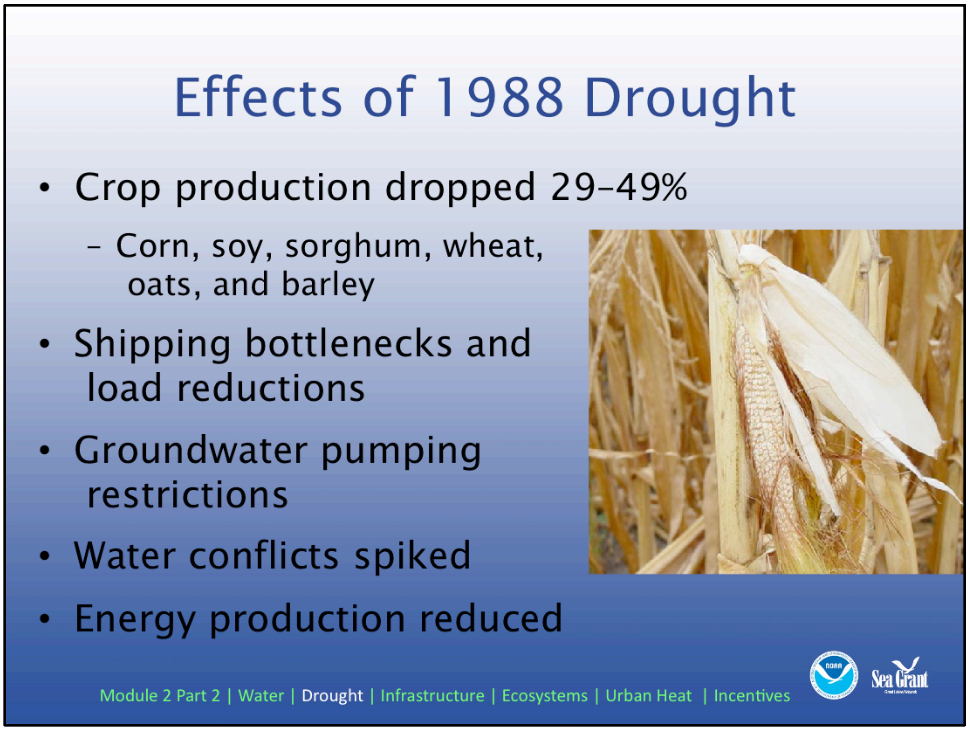


In a year with "normal" rainfall totals, the timing of precipitation led to the drought.

- Precipitation for the first 7 months of 1988 was 19% below normal. The driest period was March–July, which affected crop planting and root development.
- Moreover, an unusually hot May–June led to increased evaporation from lakes, reservoirs, and wetlands. This caused higher water demand in rural and urban areas (for example, as people watered their lawns).

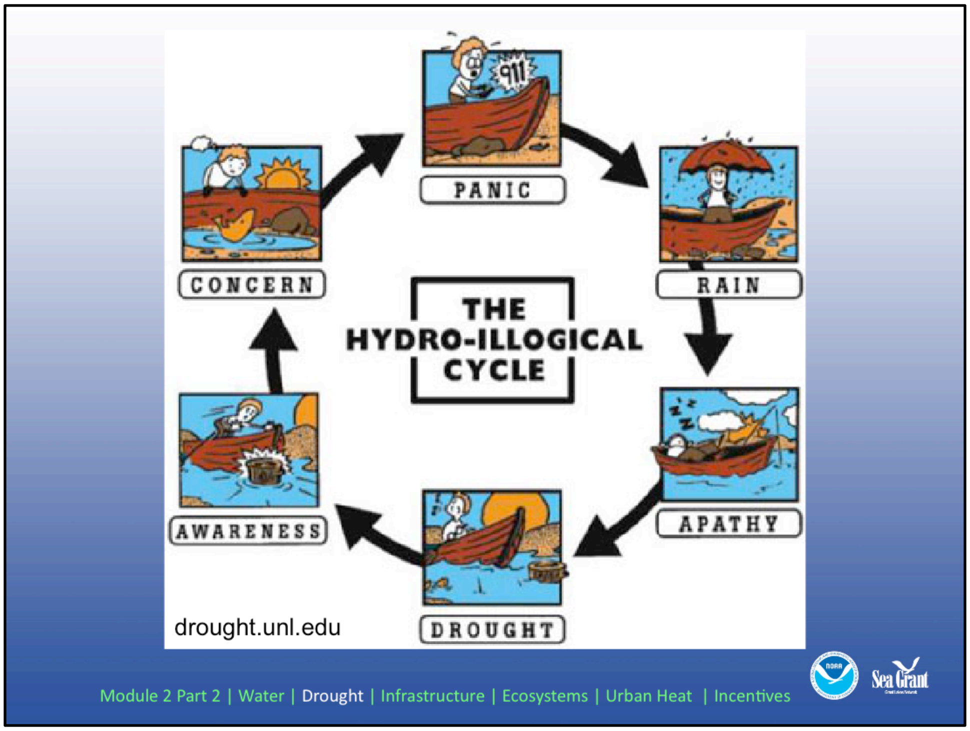
This sequence of events caused increased demand at the same time that water resources were decreasing, which hastened the reductions in streamflow and groundwater. August and December had precipitation 33% above normal, so the total for the year ended up "average."

Great Lakes Commission. 1988. *Guide to Drought Planning*.

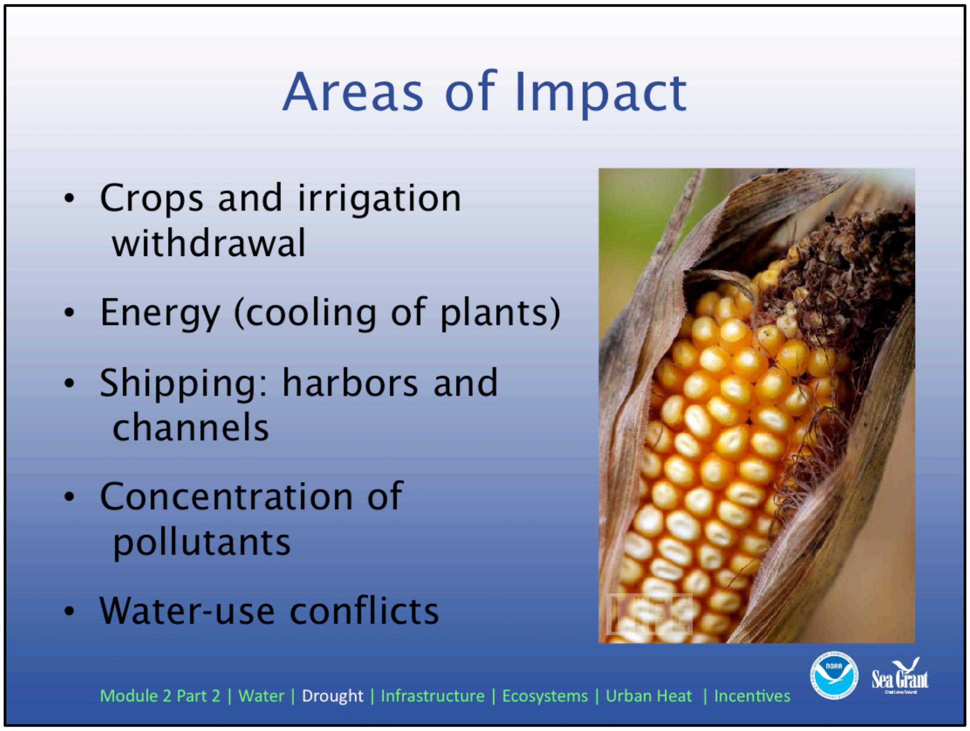


- The impact on crops varied by crop and by state. States experienced large revenue losses (for example, $1.3 billion in Wisconsin).
- Low river levels meant shipping bottlenecks on the Ohio and Mississippi rivers. Ships were diverted to Lake Michigan instead of using the canal to the Mississippi River. Ohio River barges carried 40% less cargo in June and revenue dropped 25%.
- Water conflicts developed between towns using wells, between rural and urban areas, and between agriculture and residential users.
- Electric generation in the Great Lakes relies on lake and stream water for cooling. As lake levels and stream flows drop, intake pipes are not able to draw in enough water. Ontario hydroelectric production was reduced by low water levels just as high heat increased demand.

Photo source: http://drought.unl.edu/gallery/2003/Missouri/droughtcorn.htm



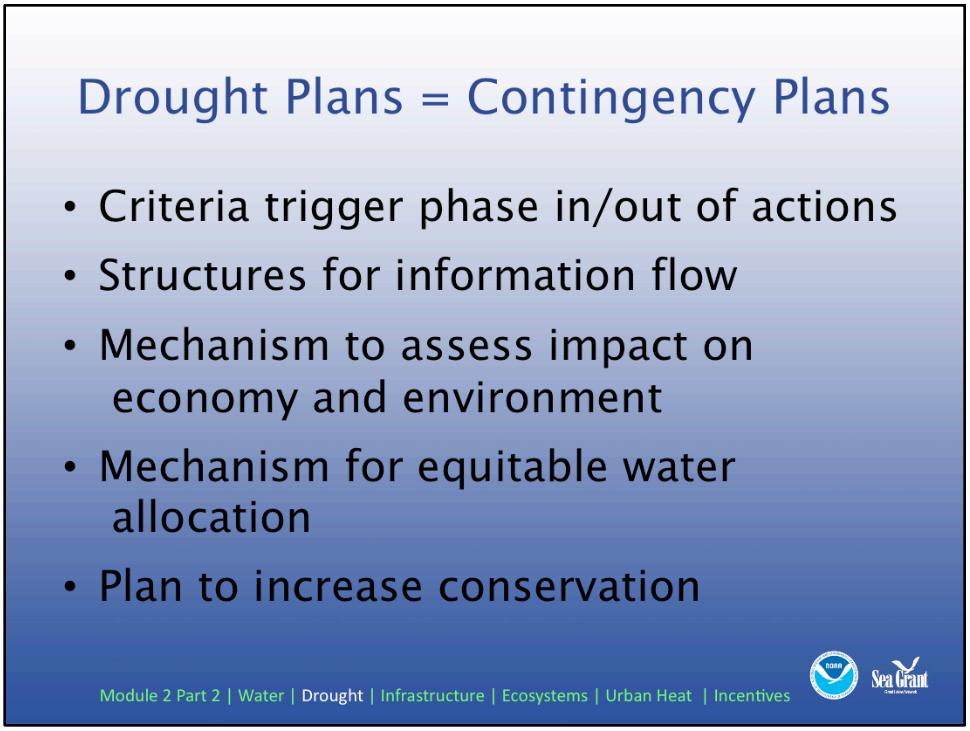
The greatest barrier to drought planning is human nature—people do not think about droughts when there is enough water.
But planning ahead is the key to mitigating drought. It is much easier to get a community to agree to appropriate contingency plans when they are not actually in a panic.



Drought affects many areas of a community:

- Crops will be require more irrigation.
- Power plants may not be able to draw as much water for cooling and will have to reduce capacity.
- Shipping channels and harbors may require more frequent dredging. Weight load will need adjustment to reduce draft depth.
- Exposed soils may have high levels of pollutants. Soils displaced by dredging may also be contaminated.
- Water users will compete and conflicts will increase.

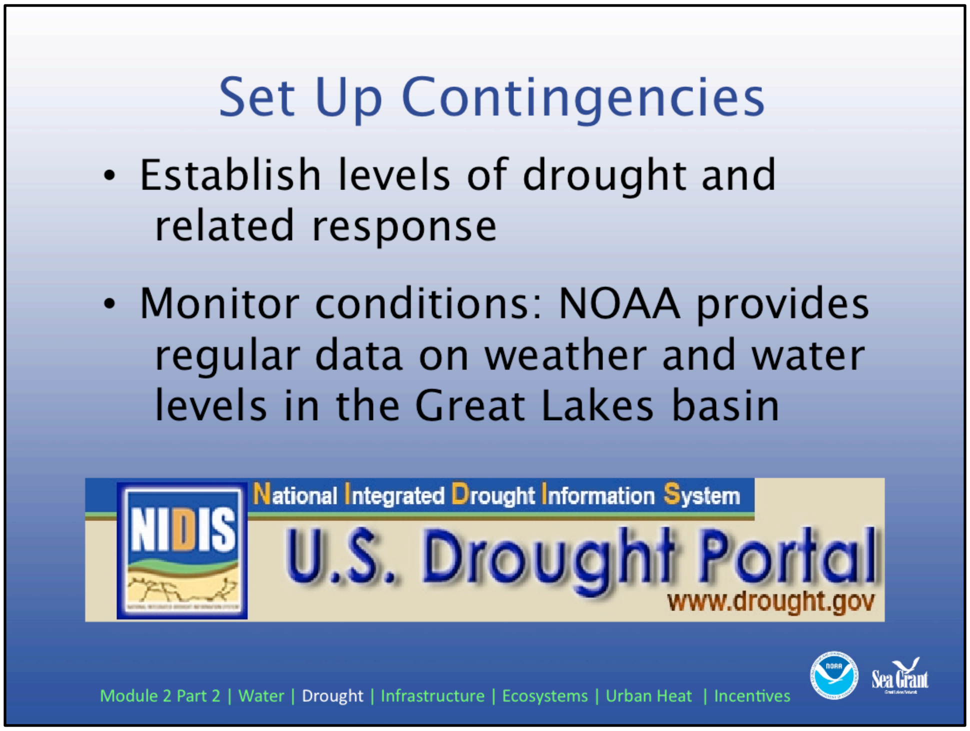
Because of this, there are lots of people in each community who need to be prepared to react appropriately if a drought occurs.



A drought plan is a contingency plan: specific actions will be triggered by defined measurements of drought severity. Implementation requires an organized flow of information among agencies, from agencies to the media, and from agencies to organizations that need to implement actions. It is best to utilize existing state or local water resources for planning and management.

The plan should:

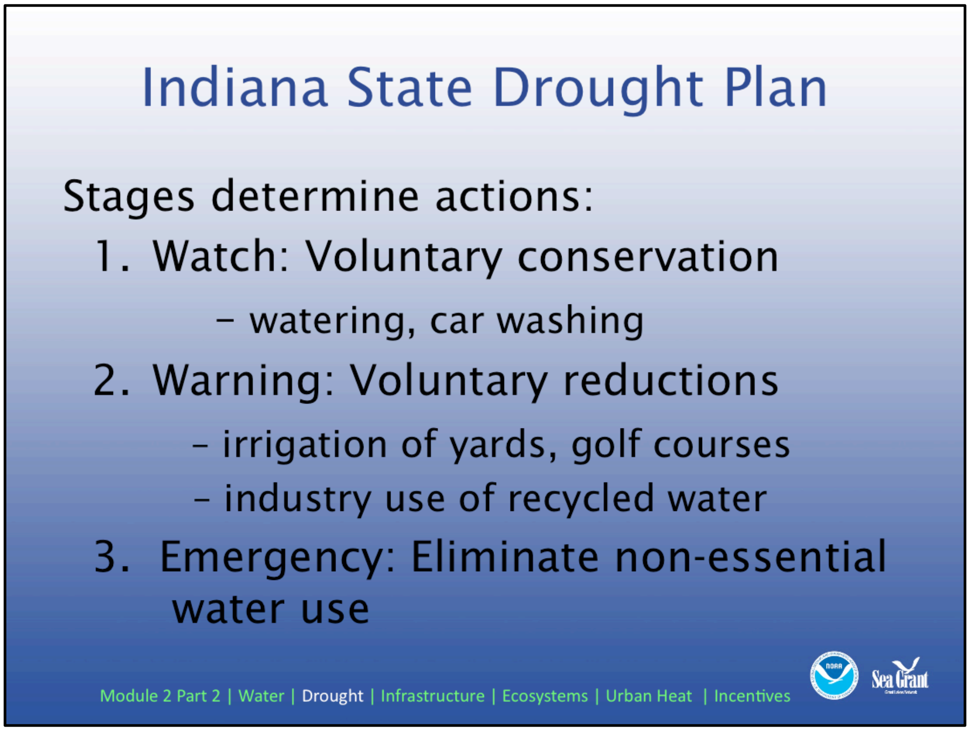
- Outline actions required for individual citizens, industry, agriculture, and government. Establishing these ahead of time reduces impacts and conflicts when drought occurs.
- Include mechanisms to assess how drought impacts the economy and environment, which helps determine priorities for water use when supplies are scarce. This helps in the equitable allocation of water.
- Consider increased conservation. Conservation is the first line of defense against drought. Educating people about conservation ahead of time can help a community respond quickly, which can be the fastest way to mitigate the impacts—especially if the drought does not last too long.



There are resources available to help with drought planning and with monitoring moisture levels to measure developing drought conditions.

The U.S. Drought Monitor synthesizes data from multiple sources and provides weekly updates, including a map of conditions for the entire United States. It draws much of its information from USDA, NOAA, and state climatologists.

Information about drought planning is available from the National Integrated Drought Information System (NIDIS).



Here is one example of a drought plan in the Great Lakes region.
Calculation of drought in Indiana is based on precipitation, streamflow, reservoir levels, groundwater levels, and soil moisture. When the index of these reaches designated levels, the plan recommends specific actions.

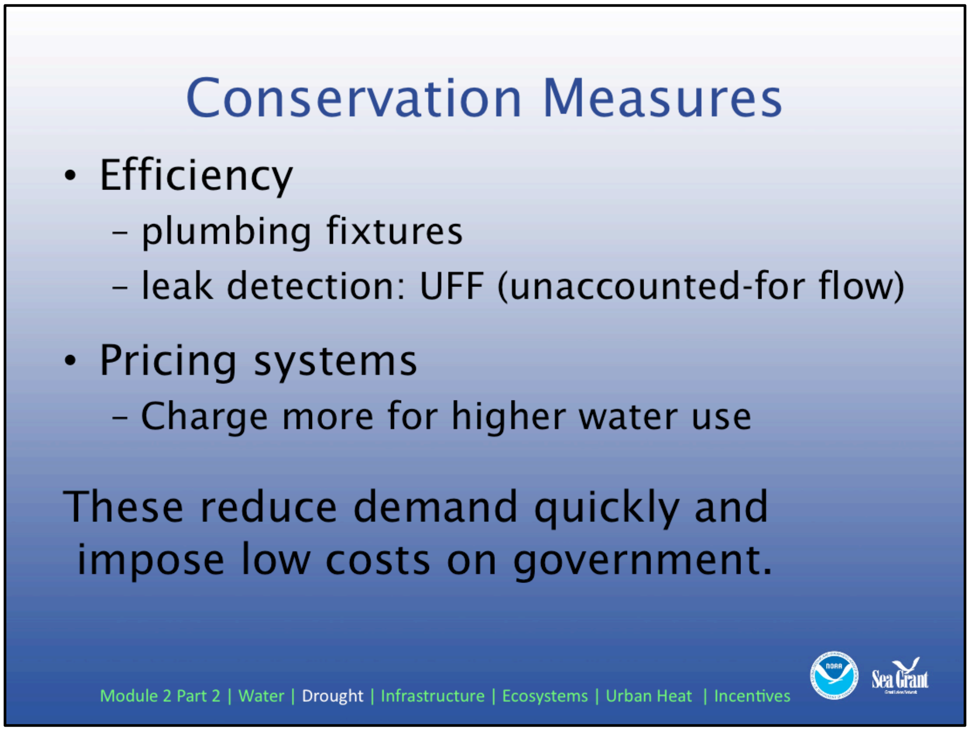
Level 1: Watch. Increase monitoring of water levels. Encourage voluntary conservation (reduction of: yard watering, outside pressure washing, and car washing; sewer and hydrant flushing; industries encouraged to use recycled water, irrigate less, and reduce employee water usage).

Level 2: Warning. Voluntary reductions in same areas as Level 1. Adds efforts to reduce irrigation water usage for agriculture, landscaping, nurseries, golf courses, recreation, and gardens.

Level 3: Emergency. Promote voluntary elimination of all non-essential water use. 15% reduction in agricultural irrigation and shifting of water withdrawals to off-peak hours.

Indiana Department of Natural Resources, Water Division. 2009. *Indiana's Water Shortage Plan*.

Indiana's plan is not very strict, since it only recommends voluntary compliance at each level of drought. This requires outreach and education to the public and industries who must join the effort. Climate change may require that states develop more stringent plans like those used in more arid western states.



Conservation is the least costly and easiest drought mitigation measure. This can be a first level of response.

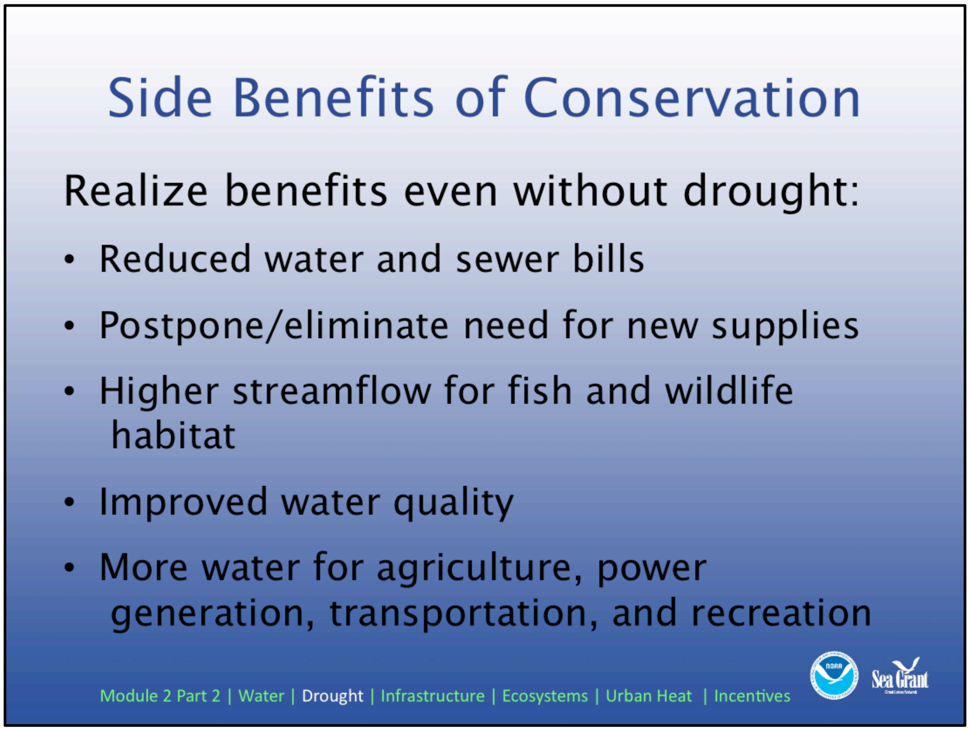
Leaks or "unaccounted-for flow" (UFF) can cause significant water waste, especially in cities like Chicago that have century-old infrastructure. Illinois now requires municipalities to have a UFF below 8% to get a Lake Michigan water allocation permit. The average UFF in the Great Lakes basin is around 15-16%.

Leakage control—water conservation by water suppliers—is a drought management strategy that supports water conservation by water users. Also, there is a big push in northeast Illinois for water metering (rather than per connection or per household flat charges), which also helps give water users direct feedback on their conservation practices.

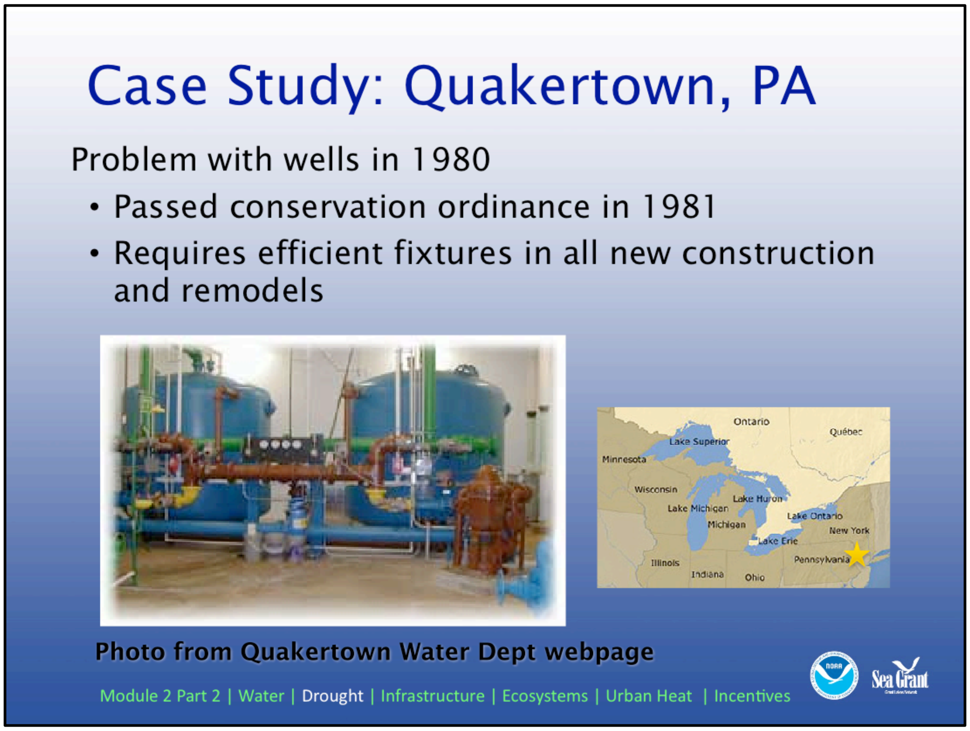
In 1988, communities reduced use by ~25% (for example, by reducing lawn watering and car washing). The Great Lakes Commission study of the 1988 drought found that most of the impacts could have been mitigated by conservation.

Here is an example of a public outreach campaign designed to encourage conservation at the household level. A campaign like this can raise public awareness, thereby making it easier to enlist community support during times of drought.

Poster source: www.nelsonmandelabay.gov.za



Conservation can be promoted by pointing out all of the side benefits to the community.



Quakertown, Pennsylvania, relies on wells for its municipal water supply. However, in 1980, the water table was low and the wells were not producing enough water to meet demands. The city developed a conservation ordinance with support from the Pennsylvania Department of Environmental Resources.

The ordinance required installation of efficient fixtures in all new construction and in all remodels. This was easy to enforce through the existing permitting process, which also included inspections of the permitted work. The municipality engaged in a public information campaign about the water shortage and the reasons for the new rules through news releases, informational brochures, displays of equipment that would meet the new guidelines, and advertising for new product lines in the stores. The ordinance has reduced water usage so that the well system is able to meet community water needs. The longer the ordinance is in place, the more buildings have efficient fixtures—so it offsets increases in population.

Source: Drought Management, 1989 and Quakertown, PA, water department webpage. http://www.quakertownboro.com/water.html

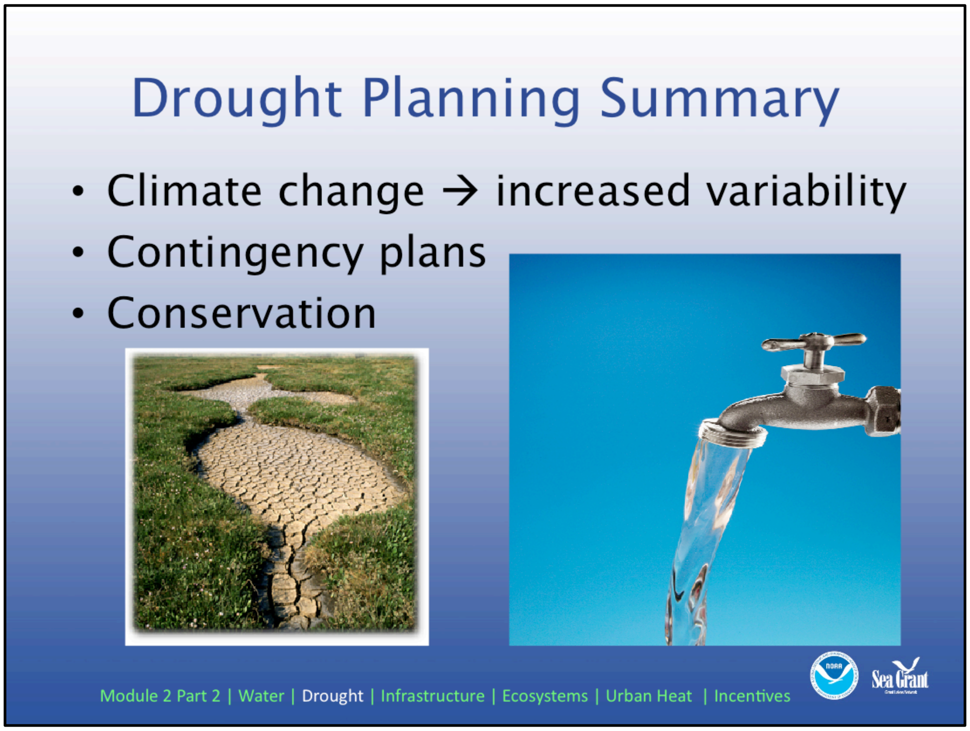
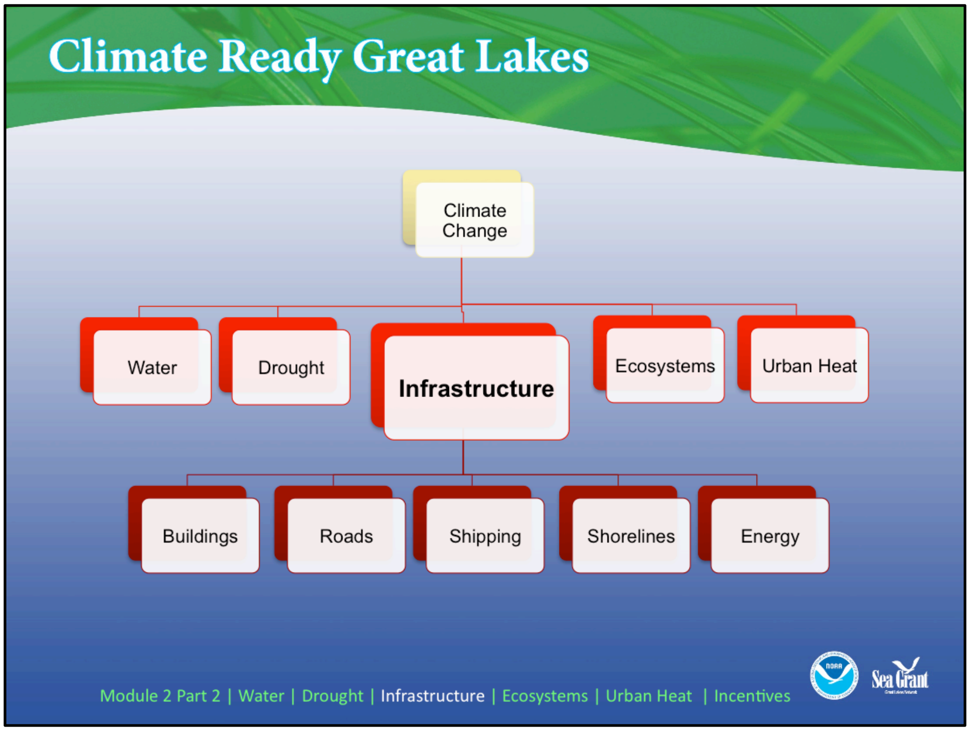
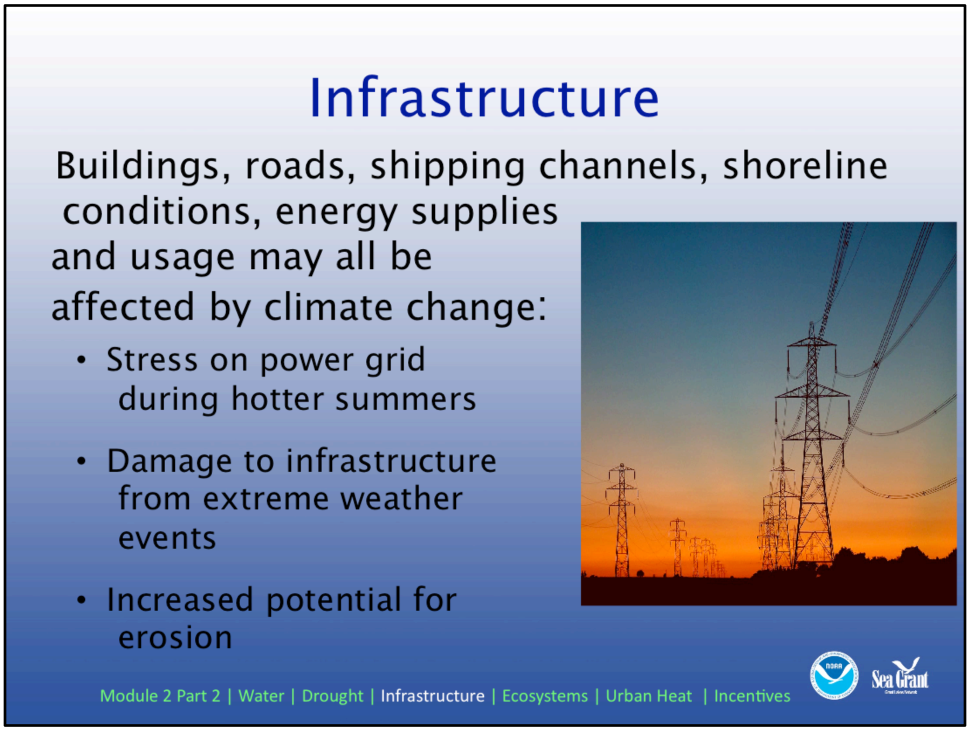


Photo sources:
http://www.greenzer.com/blog/tag/charity-water
http://www.emd.wa.gov/preparedness/prep_infocus_summerhaz_schoolprep2009.shtml



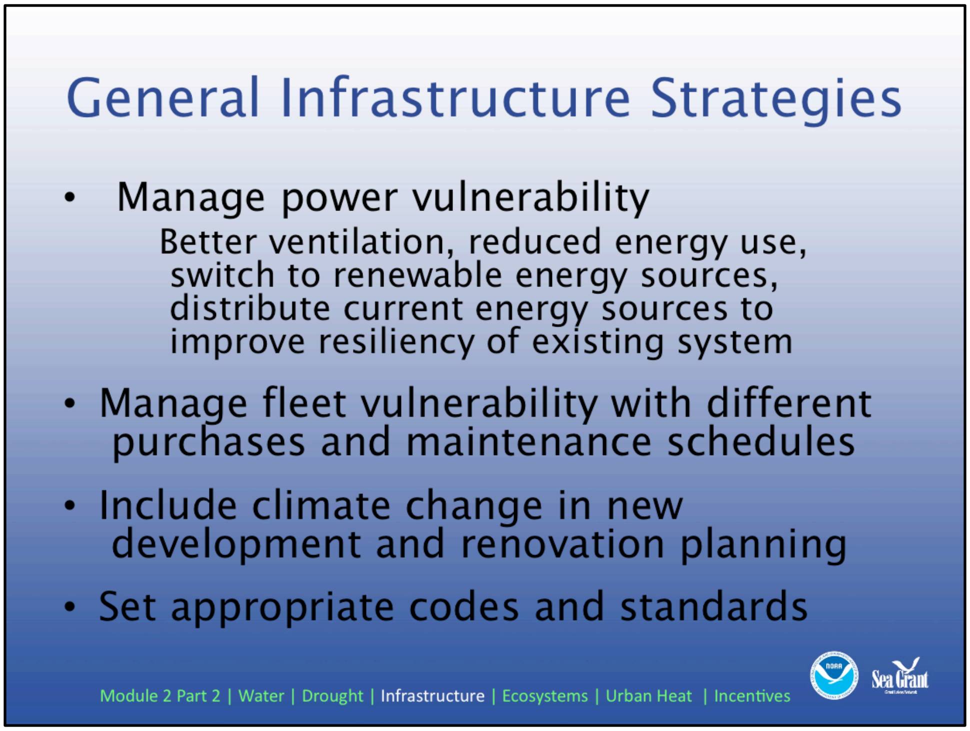
All of these areas of infrastructure will be affected by climate change, but there are ways to prepare.



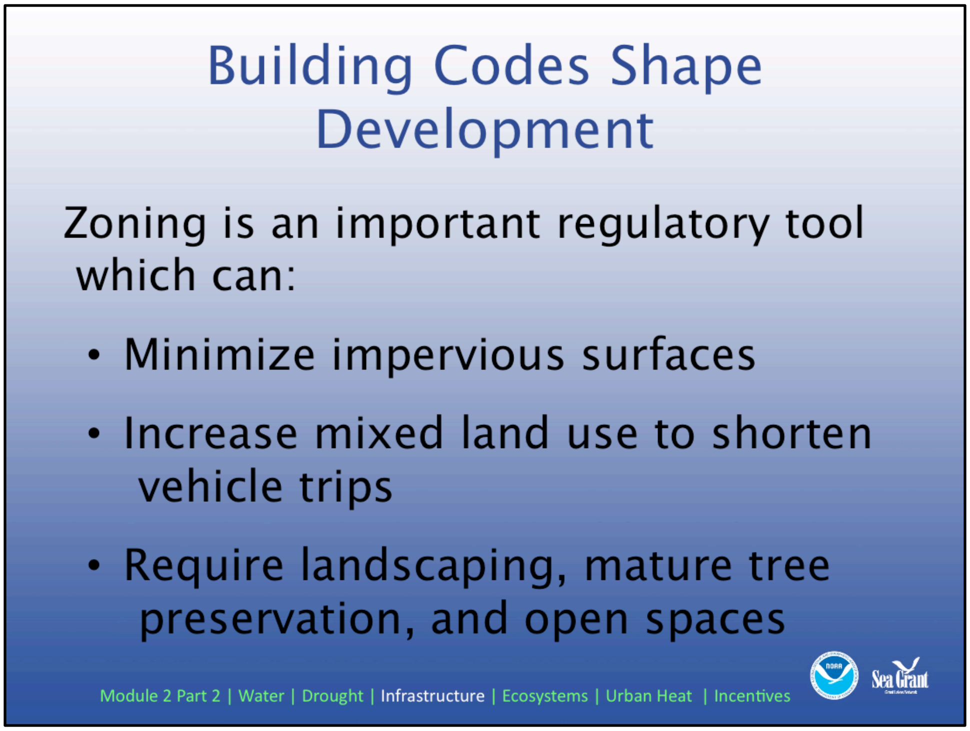
Buildings, roads, shipping channels, shoreline conditions, and energy supplies and usage may all be affected by climate change. Examples of infrastructure impacts include:

- Stress on the power grid due to more summer heat waves
- Increased annual energy costs due to probable need for additional air conditioning/cooling during summer
- Need to get greater penetration of A/C to residential units (particularly in areas of high risk resident populations)
- Increased vehicle-fleet replacement and maintenance costs
- Damage to key infrastructure (pump stations, electrical distribution equipment, etc.) caused by extreme weather events (temperature and/or precipitation)
- Increased wear on buildings due to heat and weather extremes
- Increased potential for shoreline erosion/storm damage

Photo source: http://home.uchicago.edu/~slaho/stephClass.html



Source: Chicago Climate Action Plan.



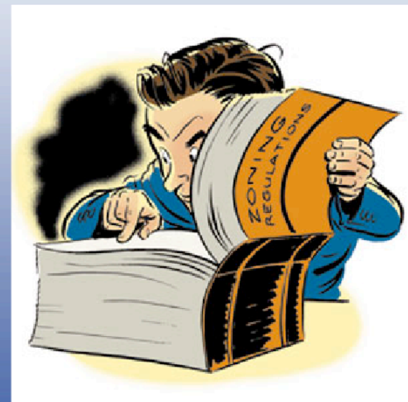
Zoning is an important regulatory tool that can:

- Minimize impervious surfaces to reduce heat island effects and water runoff.
- Increase mixed land use to shorten vehicle trips, which reduces road surface and repair and the need for parking. This also reduces paved land use and preserves natural areas.
- Require landscaping, mature tree preservation, open spaces, and other types of "green infrastructure" that help manage stormwater, reduce the heat index, and improve air and water quality.

Many of these would qualify as win-wins because they improve more than one aspect of the community.

Shoreline Infrastructure: Zoning

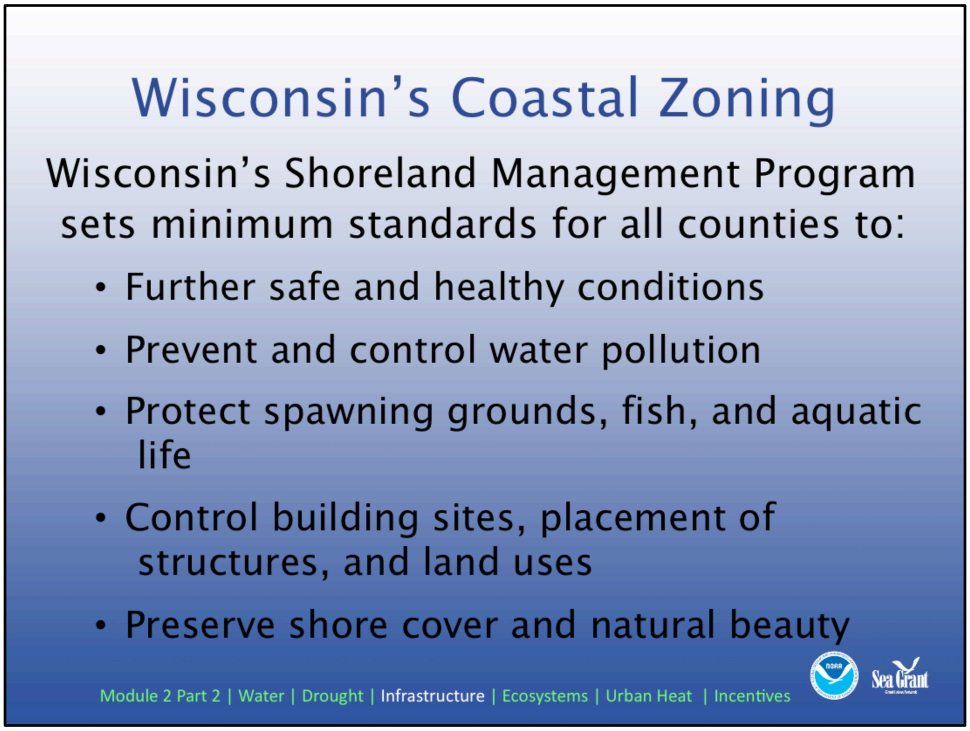
- Prevent development in expanded shore areas
- Regulate parcel use
- Determine setbacks
- Specify type of construction (e.g., easily movable)
- Require shore protection structures



Module 2 Part 2 | Water | Drought | Infrastructure | Ecosystems | Urban Heat | Incentives

Lower lake levels may increase shore area. Policies for protecting these areas from development should be established beforehand, because preventing development is cheaper than dealing with flood or storm damage if lake levels fluctuate.

Picture source: http://uhelgato.com/2010/06/zoning-in-on-zoning-laws/



Note that although this program is not designated as a climate adaptation program, all the goals help with climate adaptation needs. This is a good example of existing programs that can be linked to adaptation planning.

A model ordinance and *Creating an Effective Shoreland Zoning Ordinance: A Summary of Wisconsin Shoreland Zoning Ordinances* are available online at http://dnr.wi.gov/org/water/wm/dsfm/shore/local.htm.
NOAA, *A Planning Guide for State Coastal Managers* (2010)

Ports

- Revise loading/ unloading policies for fluctuations in lake levels
- Monitor draft depths
- Determine dredging needs

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If water levels drop, loading/unloading policies may need to be adjusted to require shallower drafts for boats entering ports.

Draft depths will need to be monitored to determine when warnings should be sent to shipping companies. A coal ship ran aground on a sand bar in Lake Michigan a few years ago and if lake levels drop, such incidents may become more frequent.

Dredging is handled by the federal government. Transport shipping needs take precedence over recreational boating areas. Communities with recreational and tourist harbors may need to start their own dredging funds.

Photo source: http://www.greencar.com/articles/plans-improve-air-quality-california-ports.php

Floating docks easily adjust for fluctuating lake levels. This type of infrastructure (common on the salty coast where tides create regular shifts in water level) can be utilized on the lakes to reduce the costs of adapting to lake-level fluctuations.

Sea Grant's Clean Marina program is designed to improve management of marinas so that they do not add stress to ecosystems. This protects the marine resources that attract the boaters to the water, so they strengthen the basis for this important element of the local economy.

Clean Marina Program
As participants in the Michigan Clean Marina Program, marinas voluntarily pledge to maintain and improve Michigan's waterways by reducing or eliminating releases of harmful substances and phasing out practices that can damage aquatic environments. To date, there are nearly 80 program participants—more than 40 marinas have pledged to work toward certification and more than 30 marinas have been awarded certification. In 2010, 13 marinas were awarded certification and 7 were re-certified.

Achieving Clean Marina Status
In order to receive official certification as a Michigan Clean Marina, participants need to complete a 10-step process, including training, a self-evaluation checklist, and a site visit. Certified marinas strive for continuous improvement in daily environmental stewardship practices. Some of the benefits to becoming a certified Clean Marina include:

- Reducing pollution and improving water quality in the Great Lakes
- Protecting fish and wildlife habitat
- Enhancing public image by promoting environmentally sound practices
- Reducing costs by adopting best management practices
- Completing Clean Marina training online

Marina owners and operators have a resource they can access 24/7 to assist in the certification process: The Clean Marina Classroom. This self-paced, online course includes details on recommended and mandatory practices of the Clean Marina Program. It includes photos and videos of best practices, nine units, and a review of relevant laws and regulations.

The text about the Clean Marina Program is from the Sea Grant website at http://www.miseagrant.umich.edu/cmp/index.html.

Shore protection structures include walls and jetties that keep sediment in place. This stabilizes the shoreline, but requires upkeep. More natural techniques like plantings and mixing vegetation with rocks can enhance the shoreline and save costs.

Photo source: http://www.merchantcircle.com/blogs/Shoreline.Design.LLC.410-956-4662/2008/5/Living-Shorelines/85824

Beach nourishment makes the beach higher and wider, in order to provide a buffer against wave action and flooding and/or to improve the recreational value of the beach.

Sand dunes serve as buffers against erosion and flood, by trapping windblown sand, storing excess beach sand, and protecting inland areas against wave runup and overwash. Sand dunes also provide habitat for wildlife. Michigan uses “a permit program that regulates earthmoving, vegetation removal, and construction activities within legally defined critical dune areas” to preserve sand dunes and manage the state shoreline.

NOAA, *A Planning Guide for State Coastal Managers* (2010)

Any Regional Sediment Management (RSM) plan should include an emphasis on the beneficial use of dredged material. A sediment management program that (1) recognizes sediment as a valuable resource and (2) links needs with appropriate opportunities will be the most effective at reducing economic and environmental losses associated with climate change.

NOAA, *A Planning Guide for State Coastal Managers* (2010)

Photo source: http://seacoastdocks.com/dredging.html

- Permanent, remotely activated warning signs free up personnel to focus on higher priority actions during an emergency.
- Housing areas that have only one entry road may need to add emergency secondary access roads. This can be added to development regulations.
- Dirt roads used for industrial transport (such as logging) often have higher weight limits during the winter, when freezing makes the roads firmer. These may need to be revised.

Energy

- Revise supply schedules
- Extend water intake pipes
- Shift power usage to off-peak hours

Chiller plant at University of Chicago

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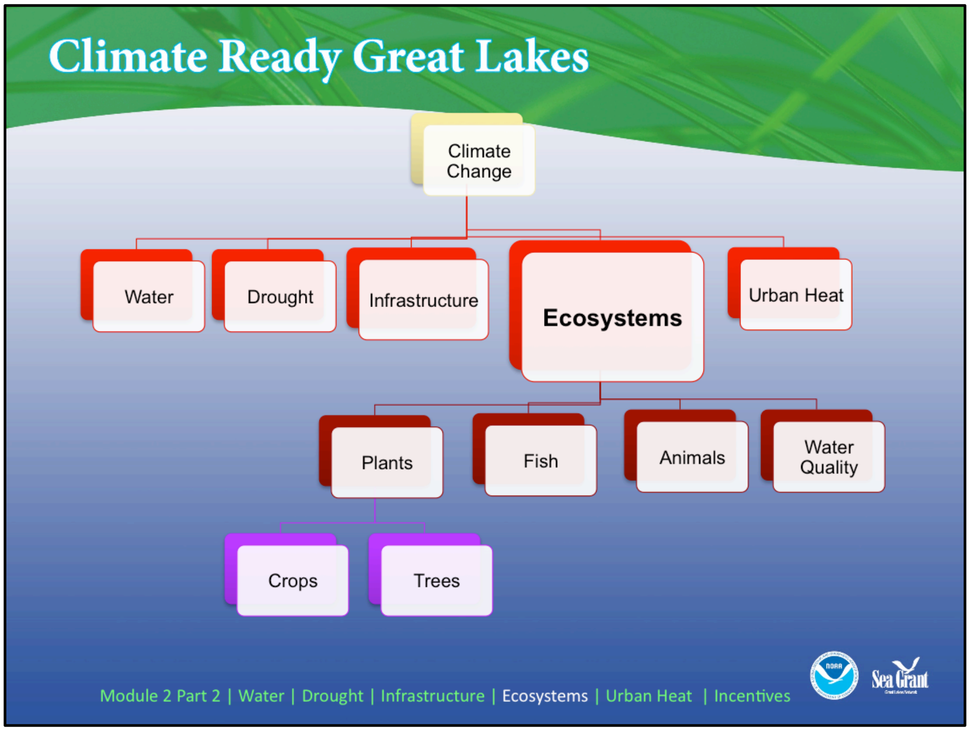
- Plants may have to adjust shipping schedules, because shallower draft means lighter loads of fuel arriving at power plants by ship.
- If lake levels drop, extending water intake pipes can help maintain cooling.
- Shifting power usage can redistribute energy loads. For example, shift large energy usage to night hours.

Consumers Energy provided Kalamazoo College with a $150,000 rebate to install the ice storage part of a chiller plant. The plant draws electricity during the night to create ice and uses the melting ice water to cool the campus during the day. The rebate funded about 75% of the cost of ice storage. The utility company saves by being able to serve increasing loads without having to build extra generating capacity. The college saves by buying power during off-peak hours when it is cheaper.

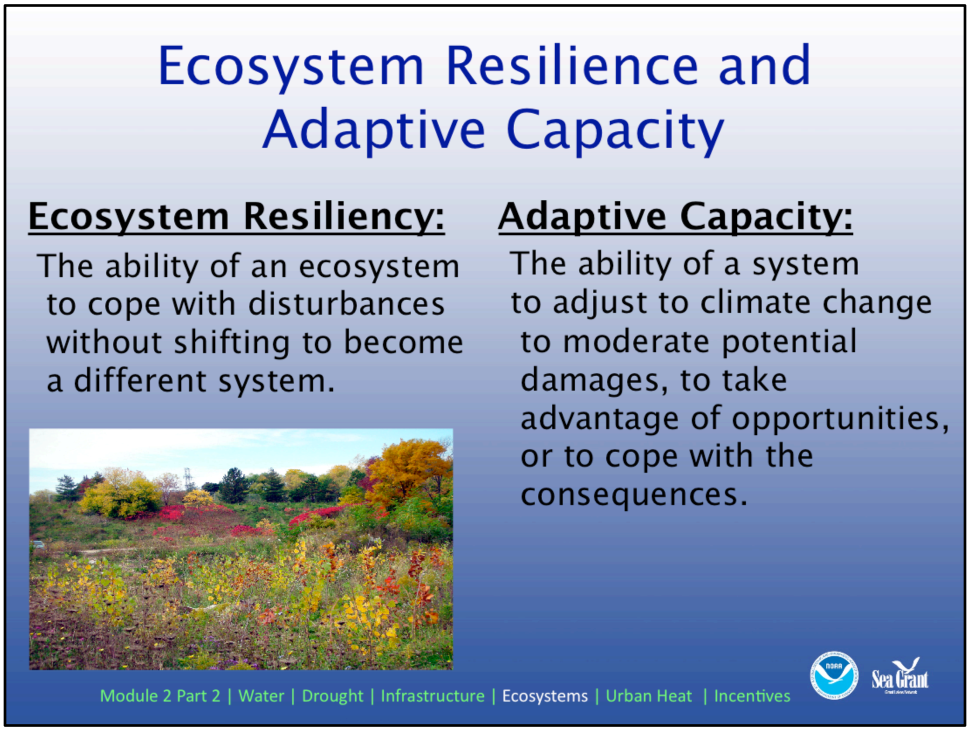
A much larger scale example of demand shifting with direct utility involvement is Consumers Energy's pumped storage facility in Ludington, where water is pumped from Lake Michigan by electric pumps during low-demand periods. This water is stored in a reservoir, which is then drained through pumps/turbines to produce electricity during the peak periods of use.

Infrastructure Summary

- Zoning
  - Buildings and shorelines
- Regulations
  - Shipping and roads
- Updated Infrastructure
  - Energy

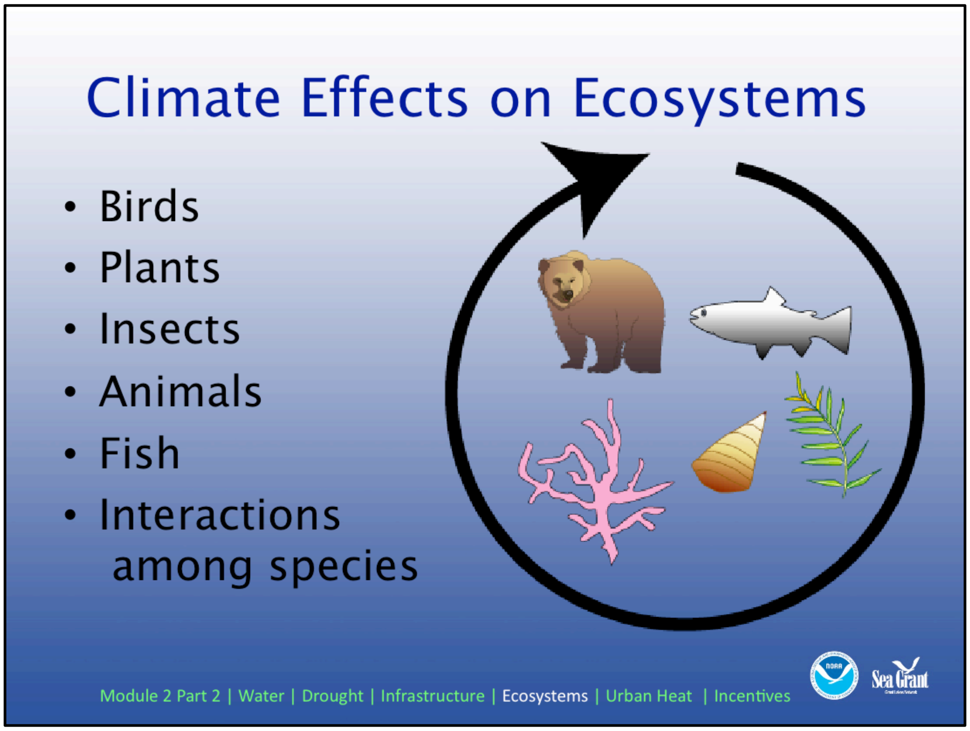


Climate change is increasing stresses on ecosystems. Reducing other causes of stress promotes resilience.



Definition source:
Climate Change Great Lakes report and the IPCC Glossary of Terms (Annex B)
http://www.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf

Photo source:
http://www.kayanase.ca/ECO.html



Climate change will touch all aspects of ecosystems, affecting:

- Bird ranges, migrations, food supply, and diseases
- Plant ranges, growth patterns, water needs, pollinator relationships, and diseases
- Insect lifecycles and ranges
- Animal ranges, habitat health, and availability
- Fish ranges and habitat quality
- Interactions among species

Good News: Win-Win Strategies

Improving ecosystem resilience helps:

- Mitigate carbon emissions
- Reduce urban heat effect
- Improve air and water quality
- Improve stormwater management
- Increase flood resiliency

Decrease Stresses on Ecosystems

- Assess strategies for invasive species
- Revise restoration guidelines/BMPs
- Prevent stormwater pollution
- Reduce pollutants in air, water, and soil
- Determine minimum stream flow levels to maintain aquatic ecosystems

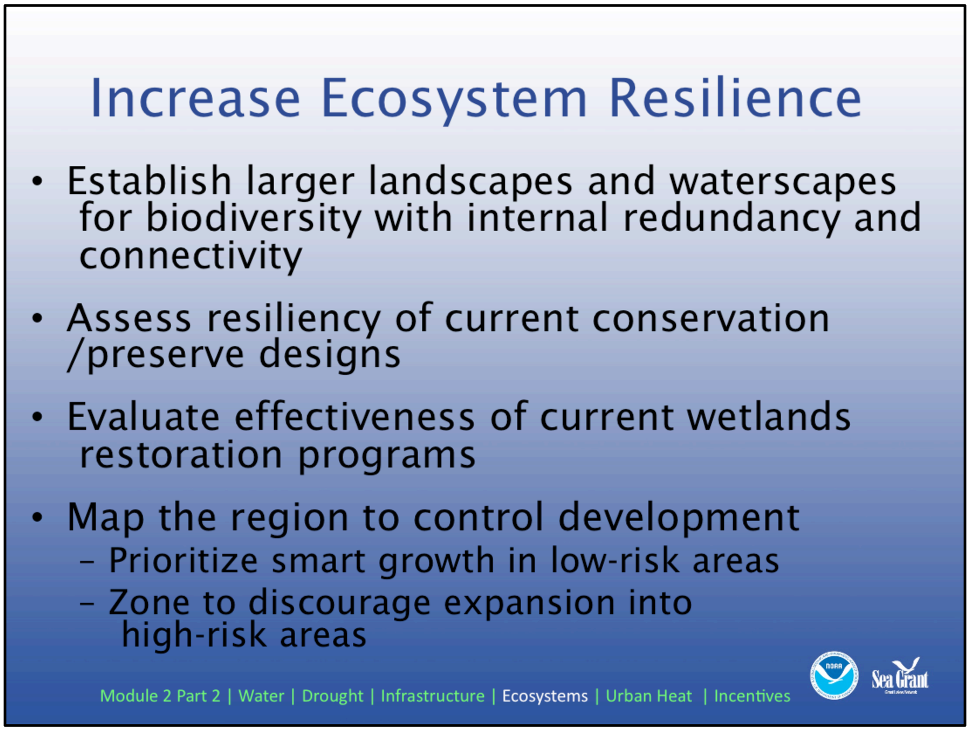
Module 2 Part 2 | Water | Drought | Infrastructure | Ecosystems | Urban Heat | Incentives

Reduce the impacts of ecological stressors that constrain the ability of native species to persist as they become stressed by changes in climate. (Note that the idea of "invasive species" is in flux. With climate change, indigenous American species are shifting their ranges; so are the native species considered invasive species when they move to a new area? This issue is made more complicated by climate change.)

Revise restoration guidelines to address new data. For example, should species of plants and fish being reintroduced be adjusted?
BMPs (Best Management Practices) can be found in state Ecosystem Management Plans and through materials provided by organizations like The Nature Conservancy.

Reduce stresses from human pollutants.

Determine minimum steam flow levels needed to maintain aquatic ecosystems. Reduced precipitation will increase competition for water; setting regulations before this becomes a problem may reduce future conflicts. This is why it is important to study an ecosystem's stream flow requirements and to incorporate these into groundwater regulations.

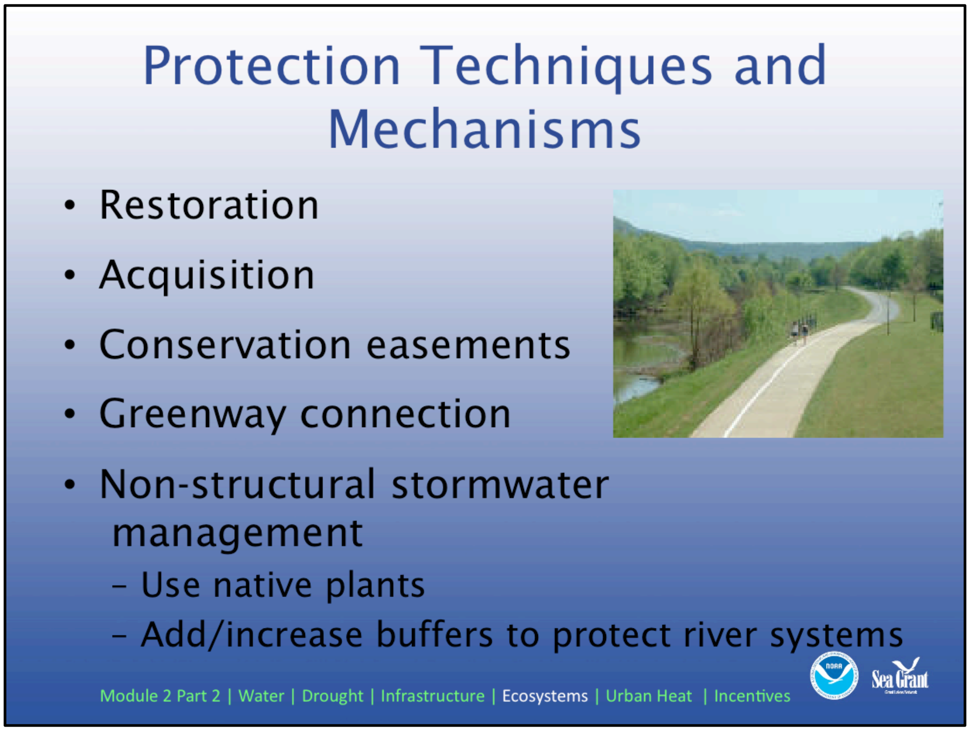


Larger landscapes and waterscapes for biodiversity with internal redundancy and connectivity.

Preserve designs need to be able to withstand disruptions in species dispersal and shifting microenvironments.

Consider most/least harm to ecosystem when planning for future development.

A good example of a comprehensive climate adaptation plan for an entire ecosystem is the *Chicago Wilderness Climate Action Plan for Nature*, which was developed by the Chicago Wilderness Climate Change Task Force in consultation with The Nature Conservancy.



- Restoration reduces stresses and increases resilience.
- Acquisition efforts focus on locating lands that are important for ecosystem health and protects these from development. The value of the ecosystem services (such as protecting water quality, reducing flood and drought risks, and increasing green space for recreation) outweighs the value of development.
- Conservation easements restrict changes in land use. These can be adjusted to permit continued farming or timber production, but prevent urbanization and impervious land cover.
- Non-structural stormwater management (using green infrastructure) can also improve ecosystem resilience. Using native plants and stream buffers are particularly good win-wins for both stormwater and ecosystems. TNC's Active Rivers model can help determine needed buffer size.

These measures can be incorporated into land-use and development guidelines.

Case Study: Northern Lower Michigan
The Conservation Resource Alliance has developed a River Care program to provide technical and financial support so that local groups can restore trout streams degraded by timber harvesting. This program uses its knowledge to help direct restoration to where it will be most effective and to leverage sources of funding. It has proven quite successful.
(There is more information of this case in the supplemental materials.)

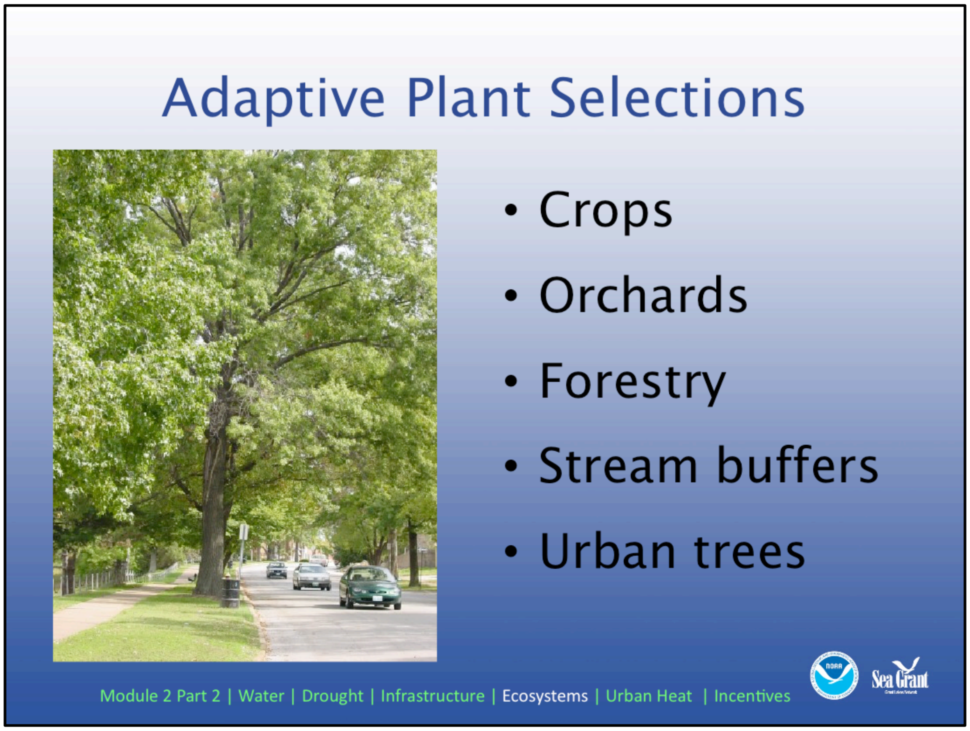
Photo source: http://www.hsvcity.com/gis/greenways/aldridge.htm

Ecosystem-based adaptation:

Best management practices for agriculture

Module 2 Part 2 | Water | Drought | Infrastructure | Ecosystems | Urban Heat | Incentives

- Setting up buffers along streams that run through agricultural land protects the water from pollutants, while also providing habitat and connective corridors for wildlife.
- Trees and vegetation used in the buffers can be selected from native plants with wide ranges of temperature tolerances to ensure greatest resilience.
- Some plants are especially good at absorbing pollutants—these could be utilized in areas with urban runoff concerns.
- Trees play an important role in ecosystem adaptation because their shade helps cool stream, which reduces stress on aquatic ecosystems.



Adaptation planning includes making appropriate plant selections.

- **Crops:** Farmers may need to choose varieties of seed that fit new climate patterns.
- **Trees:** Trees can't quickly be exchanged for new varieties, so advance planning is important. This is another example of anticipation being easier and more effective than reaction.
- **Orchards:** Farmers may need to increase the varieties of fruits they grow, so they have a mix of earlier and later bloom times and a range of harvest cycles. This will help ensure that weather fluctuations from year to year will not eliminate entire crops.
- **Forestry:** State forestry programs are already taking climate into consideration in their tree planting programs by adjusting the mix of species they use.
- **Urban trees:** Cities need to consider long-term climate predictions when deciding what species to plant along streets and in parks. Most cities have lists of approved trees for urban planting, so these need to be updated.

Land trusts are "non-profit organizations that work with landowners and the community to conserve land by acquiring conservation easements or providing stewardship on the land" (www.landtrustalliance.org/conserve/about-land-trusts). Valuable lands are those with most potential to aid with adaptation.

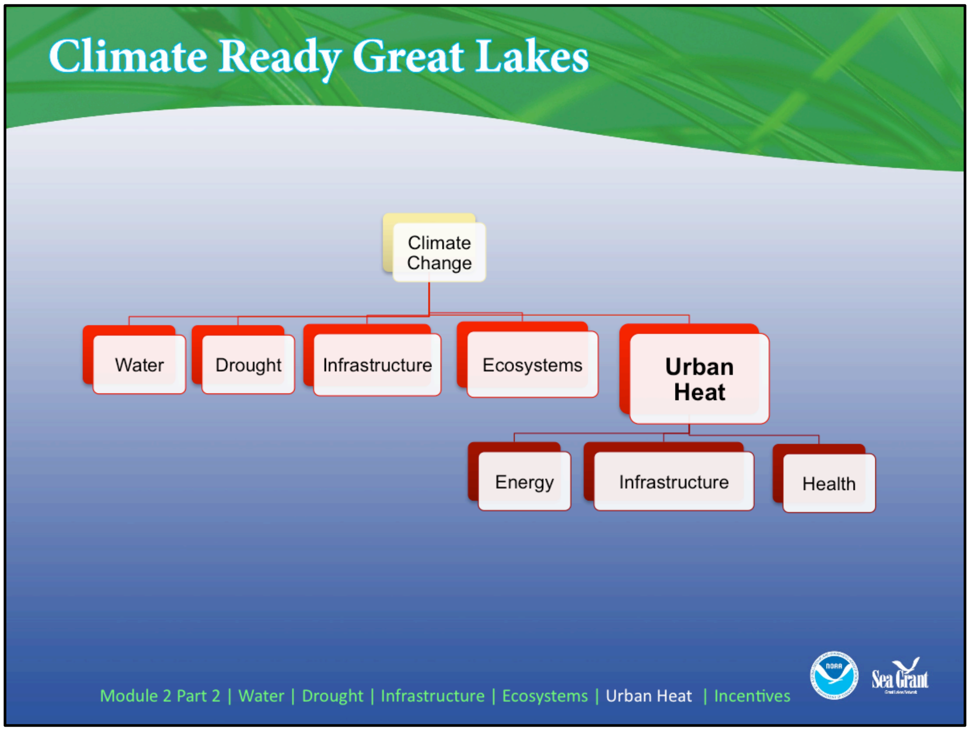
Case Study: Milwaukee, Wisconsin
Milwaukee Metropolitan Sewerage District partnered with the Conservation Fund to manage floodplains in the Milwaukee watershed. The plan identifies undeveloped private properties that could provide future flood prevention benefits, but that are at risk for development. The Conservation Fund then works to acquire properties through conservation easements or outright purchase.

Case Study: Northwest Lower Michigan
The Conservation Resource Alliance realized they could not buy up all the timber lands going on the market to preserve connectivity corridors so they created education campaigns to provide new landowners with information about the importance of connectivity and a variety of ways they could improve ecosystems for wildlife on their land. Letting the private landowners have control over their own decisions has proven effective.
(More information about this case is provided in the supplemental materials for this module.)

Photo source: http://flooksolutions.com/id4.html

Summary of Ecosystems

- Increase resiliency by reducing stress
  - Reduce pollution
  - Increase buffers and connectivity
- Win-wins:
  - improved quality of ecosystems
  - Improved quality of human life


Climate Ready Great Lakes
Climate Change
Water
Drought
Infrastructure
Ecosystems
Urban Heat
Energy
Infrastructure
Health
Module 2 Part 2 | Water | Drought | Infrastructure | Ecosystems | Urban Heat | Incentives

Urban Heat Islands (UHI)

- Thermal energy from impermeable surfaces causes higher temperatures in dense urban areas.
- Hot days can raise city temps 4-10°F.
- UHI could increase energy demands, roadwear, fires, power outages, city services, respiratory problems, and heat stroke.

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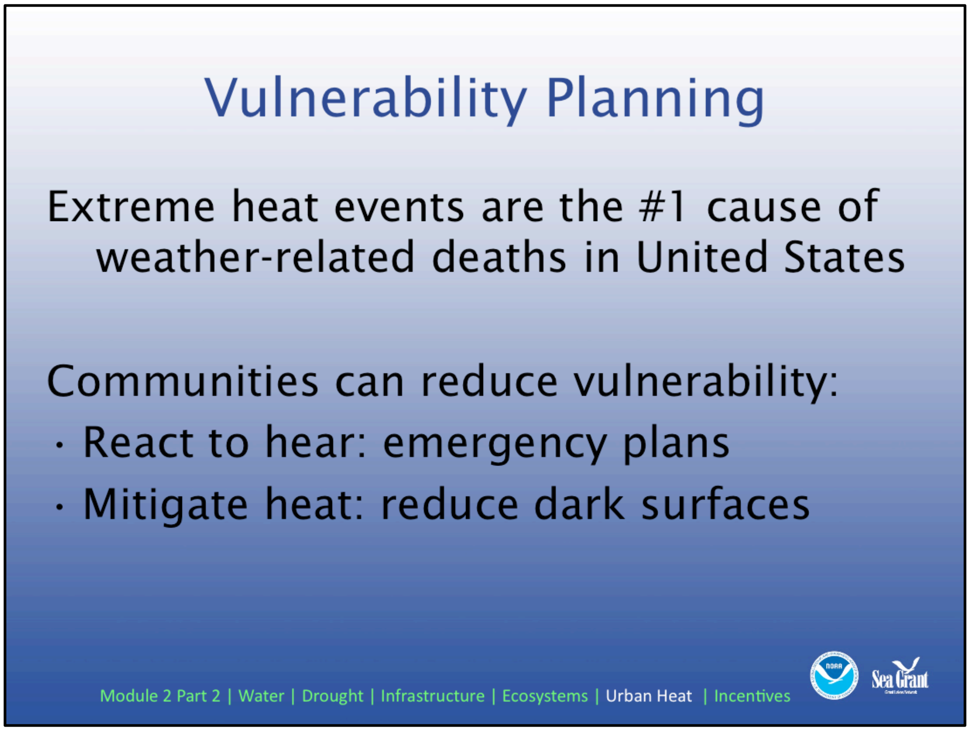
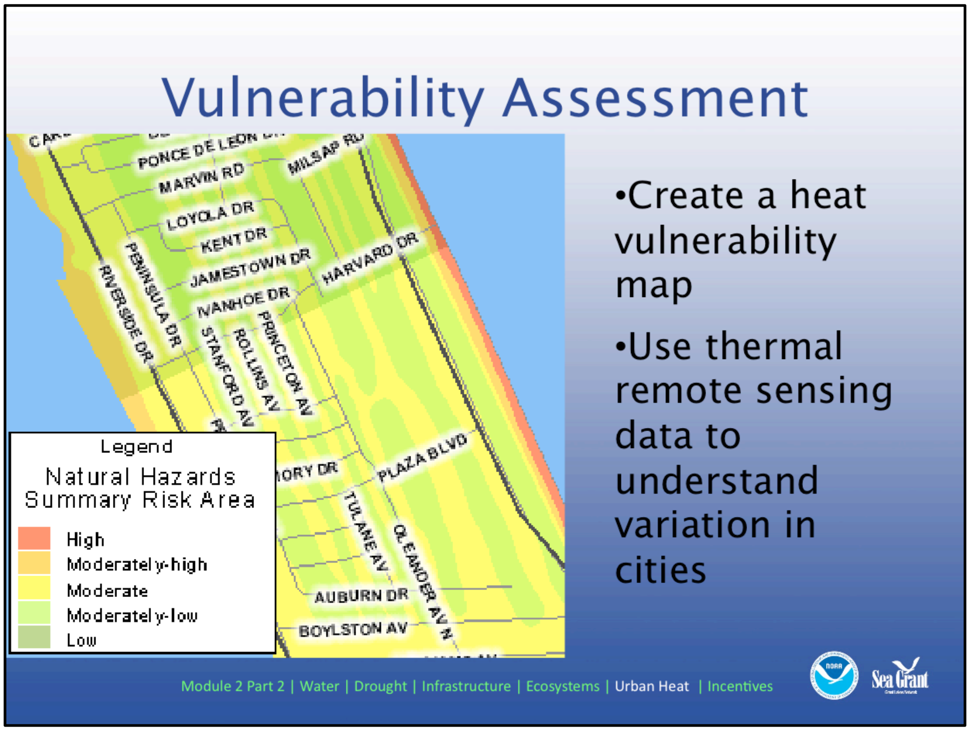


Emergency response plans are activated when heat rises above a specified level. These plans may include sending out requests for neighbors to check on each other, setting up cooling centers and providing transportation to bring people to spend the day, providing free public transit to city swimming pools, and distributing fans.

Mitigation involves reducing the dark surfaces that transform light into heat and raise the temperature. This can be achieved by changing roof colors and adding green space.



Identifying the hottest areas helps a city target its emergency response plans. Thermal data can be combined with neighborhood information about types of buildings, income levels, and ages of residents. Low-income areas with older building are less likely to have air conditioning, and senior citizens are susceptible to heat-related health problems. These high risk areas may also have less green space and limited access to transportation.

Module 3 describes tools that can help with thermal remote sensing data.

Extreme Heat Mitigation and Planning

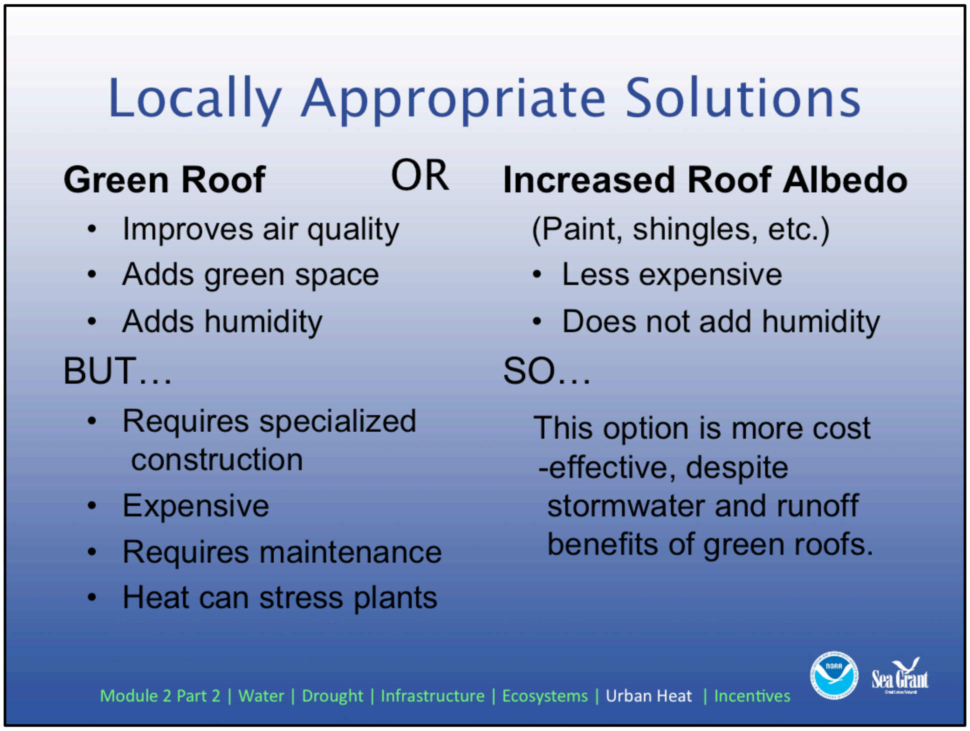
Greenery:

- Reduces heat
- Provides shade
- Improves air quality
- Is economically efficient

This picture of a park area along Lake Shore Drive in Chicago shores the tree barrier that can block the flow of air.

- Tall trees and banks of trees that are parallel to the shoreline can block the flow of wind as it shifts directions throughout the day.
- Alleyways of trees perpendicular to the shore will let more wind flow through and are more effective for reducing heat. Shorter trees let more air through, but still provide park shade.

Photo source: travel.webshots.com



There may be cases where a green roof is the best choice. For example, a large city may benefit from increasing green space since that adds outdoor space, improves air quality, and can increase humidity. However, green roofs are more expensive and are probably not appropriate for smaller towns—especially if humidity is already high.

Summary of Urban Heat

Emergency planning:

- Cooling centers
- Transit to pools

Reduce dark surfaces:

- Lighten roofs
- Increase green space

This section provides an overview of resources that can help with implementation of adaptation measures

Most financing approaches for adaptation are reactive—responding to a crisis instead of trying to prevent one. Shifting to an approach that has an adaptation financing structure built-in to local policies would give communities more flexibility to respond to climate change challenges as they happen.

Source: Preparing for Climate Change in the Great Lakes Region, Sea Grant and UM

Photo source: http://www.usm.edu/aredjournal/archive_ared/archives_pages/topically_archives_home.html

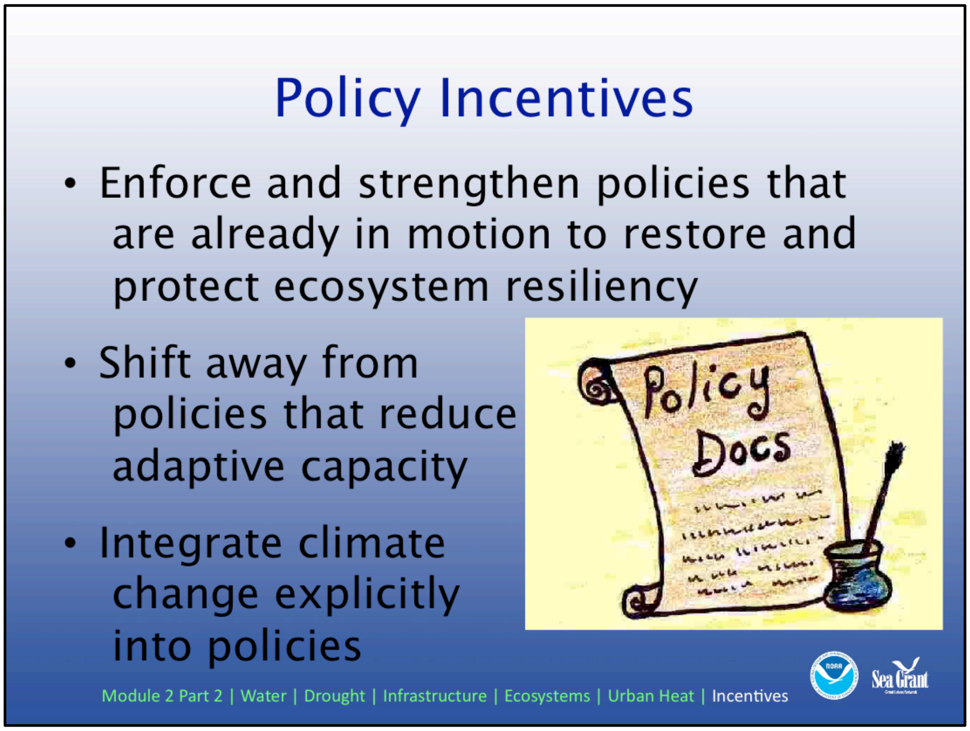
Fiscal Incentives

- Use finances to discourage damage to ecological resiliency and encourage increased adaptive capacity
- Adjust existing financing mechanisms to support activities that increase adaptive capacity

Communities can use fiscal incentives (such as tax structure, subsidies, and funding opportunities) to discourage actions that damage ecological resiliency and encourage those that increase adaptive capacity. For example, communities could charge for actions that reduce ecological resiliency, such as development that damages a wetland. This could create a pool of funding for restoration and adaptation measures—such as providing subsidies for actions that increase resiliency (for example, wetland restoration).

Additionally, existing financing mechanisms could be tweaked to support activities that increase adaptive capacity. For example, the Clean Water State Revolving Fund is a low-interest loan financing program that assists municipalities with funding water quality projects. This fund currently supports grey infrastructure projects (i.e., bricks and mortar construction), but could shift to focus on green infrastructure (such as constructing green roofs or bioswales).

Source: Preparing for Climate Change in the Great Lakes Region, Sea Grant and UM
Photo source: http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Pages/DelawareWetlandsConservationStrategy.aspx



Communities could also enforce and strengthen policies that are already in motion to restore and protect ecosystem resiliency, as well as shifting away from policies that reduce adaptive capacity. One example would be phasing out perverse subsidies (such as insurance programs that encourage development in floodplains and vulnerable coastal zones).

Communities could also explicitly integrate climate change into existing and new policies, such as shoreline ownership and pollution permitting. One example of this would be updating floodplain permits to align with the new FEMA flood maps that have recently been released.

Local governments can create their own incentives to promote climate resiliency such as:

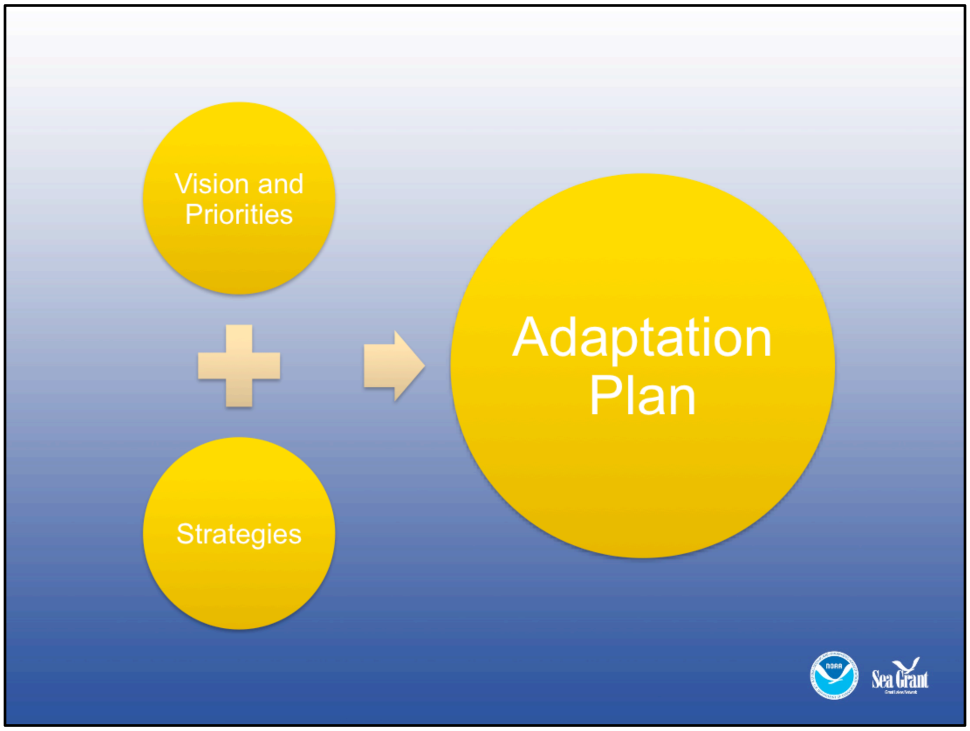
- Expedite plan review and other financial incentives for projects that meet or exceed climate objectives
- Waive permit fees for projects that enhance ecosystem resiliency and/or adaptive capacity
- Give rebate and trade-in incentives for home and business upgrades on environmentally-friendly products
- Provide technical assistance to help developers meet new goals and standards—and give financial incentives to developers whose projects meet predetermined standards
- Offer community financing mechanisms to offset start-up costs for green infrastructure projects

Funding and Policy Resources

See handouts for more information on:

- Potential funding sources
- Federal laws and executive orders relevant to climate change on the coast

From NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers*



The planning process outlined in the first part of this presentation sets the framework for assessing what climate impacts are most likely to affect a specific community. With this background, people can evaluate strategies for climate adaptation that are locally appropriate. A sample of such strategies were covered in the second part of the presentation, but there are many more ideas than could be included here. Hopefully, this introduction to adaptation planning and adaptive measures has given you a sense of what is possible—so that you have a place from which to start developing a climate adaptation plan.

Note: Worksheet 2 can be handed out and used to help workshop participants start applying the information in Module 2 Part 2 to their own communities. This worksheet will ask them to think about adaptation strategies to address climate impacts they have identified as likely to affect them. Then it asks them to think about how many different climate impacts could be addressed with the same strategies—this will lead to discussion of win-wins, and the possibility of locating shared resources across municipal departments.

Climate Ready Great Lakes

Worksheet 1: Assessing vulnerabilities

Directions: Identify 3 climate change impacts from the box to the right, and list them in the left-hand column **A** below. For each impact, list one effect it will have on your community in the corresponding line in the right-hand column **B**.

Anticipated impacts of climate change in the Great Lakes Region:

- Fluctuating lake levels
- Less lake ice
- Frequent severe precipitation events
- Longer dry periods
- Hotter summers

<u>**A.** Climate change impact:</u>	<u>**B.** Effects on community:</u>
1.	1.
2.	2.
3.	3.

Impacts (from list **A**)	**1.**	**2.**	**3.**
What community services and/or infrastructure will be affected and how will they be affected?			
Are there overlaps among the effects of the three impacts?			
When will it affect people? Now/10/20/40 yrs			
How would you prioritize which impacts to address?			

Climate Ready Great Lakes

Worksheet 2: Choosing Strategies

You have seen a range of adaptation strategies related to some of the following topics: stormwater management, flood and drought prevention, infrastructure, ecosystem resilience, and urban heat.

Take the three climate impacts you identified in Worksheet 1and place them in the numbered boxes in this chart. Choose strategies that can mitigate each of these impacts. The box on the right gives a partial list of strategies.

E.g. If stormwater management is a concern, maybe you would select green infrastructure as one promising strategy.

Some sample strategies:
- green infrastructure
- land use planning
- stream buffers
- tree planting
- water conservation
- zoning
- regulatory changes
- energy distribution
- light-colored roofing
- ecosystem restoration

Climate change Impact	1.	2.	3.
What strategy can help mitigate the impact? *How* does it reduce the problem?			
What other climate impacts does this strategy address?			
What data do you need to determine how effective this strategy would be in your area? Where might you acquire that data?			
What agencies or organizations would be responsible for implementing this strategy? (Name as many as you can think of.)			
Are there ways to share costs? E.g. through joint projects?			

Case Study Examples

Planning Processes

Connecting to Existing Planning Processes (Marin County, CA) - Marin County made sustainability the overarching theme of its communitywide planning process. This made it possible to utilize existing resources for the processes of planning and implementation.[1]

Public Participation Improves Implementation (Green Bay, WI) - The Green Bay Remedial Action Plan incorporated citizens into the planning process through creation of a Citizens Advisory Committee and developing information on indicators of ecosystem health that were accessible to the public in order to facilitate joint discussion. The public helped determine problems and solutions and had an active role in the decision making process. This helped gain support for measures that required both public and private action.[2]

Economic Analysis of options (Green Bay, WI) - Using existing data, a research team concluded that it was much less expensive to control sources of suspended solids upstream than to purify water in municipal treatment plants. ($.008 per pound vs $4.61)[3]

Stormwater Management

Revised Stormwater Rate Structure (Ann Arbor, Michigan) – Stormwater utility rates are determined by the amount of impervious area on a property instead of a uniform rate structure.[4]

Downspout Disconnection Program (Toronto, Ontario) – All Toronto homeowners are required to disconnect their downspouts that had been connected to the combined sewer system.[5]

Discounted Rain Barrels (Milwaukee, Wisconsin) – The city purchased rain barrels in bulk and sold them at discounted prices to residents.[6]

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[1] American Planning Association. 2010. *Planning for a New Energy and Climate Future* pp. 50-51

[2] Harris, Victoria A. 1992. "From Plan to Action: The Green Bay Experience." In *Under Raps: Toward Grassroots Ecological Democracy in the Great Lakes Basin*, ed. John H. Hartig and Michael A. Zarull. Ann Arbor: University of Michigan Press. Pp. 37-58.

[3] White, David, Paul Baumgart, and Bruce Johnson, eds. 1995. "Toward a Cost-Effective Approach to Water Resource Management in the Fox-Wolf River Basin: A First Cut Analysis." Green Bay: Northeast Wisconsin Water of Tomorrow

[4] http://www.a2gov.org/government/publicservices/systems_planning/waterresources/P ages/StormWater.aspx

[5] http://www.toronto.ca/water/protecting_quality/downspout.htm

[6] http://v2.mmsd.com/RainBarrels.aspx

Case Study Examples

Green Roof Grants Program (Chicago, Illinois) – Residential and small commercial building owners can apply for a $5,000 grant to help with the planning and installation of a green roof.[7]

Protecting Groundwater Recharge Areas (Austin, Texas) – The city uses conservation easements and the purchase of development rights to protect groundwater recharge areas.[8]

Floodplain Protection and Restoration (Milwaukee, Wisconsin) – The Milwaukee Metropolitan Sewerage District has partnered with the Conservation Fund to protect and restore floodplains in the Milwaukee watershed. The program identifies undeveloped private properties which could provide future flood prevention benefits, but that are at risk for development. The Conservation Fund then works to acquire those properties through conservation easements or outright purchase.[9]

Comprehensive Policy Revision (Olympia, Washington) –Revision of multiple aspects of planning and development, including development density, impervious surface coverage, lot size, open space/tree retention, street design, street width, block sizes, parking, sidewalks, and stormwater management requirements.[10]

Ecosystem Management

Regional Collaboration (Saginaw Bay, Michigan) - The Saginaw Bay Greenways Collaborative brings together local, state, and federal agencies, concerned citizens, and nonprofit organizations who all share a goal of developing a system that can harmonize "green" and "grey" infrastructure. This will support wildlife, water quality, recreation, urban and land-use planning, tourism, and economic development.[11]

Public and Private Cooperation (Northwest Lower Michigan) - The Conservation Resource Alliance works to protect regional watersheds. The Wild Link Program supplements public conservation areas by encouraging private landowners to help preserve connective corridors for wildlife. The River Care

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[7] For more information, see http://egov.cityofchicago.org/city
[8] http://www.ci.austin.tx.us/water/wildland/default.htm
[9] http:www.conservationfund.org/node/404
[10] http://www.psparchives.com/publications/our_work/stormwater/lid/ordinances/Green_Cove.pdf
[11] http://www.greeninfrastructure.net/sites/greeninfrastructure.net/files/4-FINALSag%20Bay%2007.18.05.pdf

Program helps local citizens restore trout stream habitat damaged by 19th and 20th century logging.[12]

Remediation Restores Resiliency (Collingwood Harbour, Ontario) - Collingwood Harbour demonstrates successful implementation of a Remedial Action Plan. The process successfully removed contaminated sediments, and reversed eutrophication and losses of fish and wildlife habitat. Further, the RAP led to new pollution prevention and water conservation initiatives in the area.[13]

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[12] http://www.greeninfrastructure.net/sites/greeninfrastructure.net/files/5-CRA%2008.30.05_0.pdf

[13] Krantzberg, Gail, and E. Houghton. 1996. "The Remedial Action Plan That Led to the Cleanup and Delisting of Collingwood Harbour as an Area of Concern," *Journal of Great Lakes Research* 22, 2: 469-483.

Module 2 Case Studies:
Background Data

PLANNING PROCESSES

Connecting to Existing Planning Processes (Marin County, CA)

Marin County folded sustainability into its regularly scheduled planning processes, thereby leveraging existing resources. Thus, the Countywide Plan (2007) was able to incorporate climate change mitigation and adaptation efforts into land use, energy conservation, green building, transportation, and waste disposal in accord with the California state requirement that county general plans guide physical development. Marin also includes social equity, public health, environmental justice, child care, the economy, arts, and culture in its countywide plans, so these too are now required to incorporate sustainability.

The process for updating the plan began in 2000. At that time, staff chose "planning sustainable communities" as a theme for the whole plan so that sustainability principles would be incorporated throughout rather than placed into a separate section. In 2002, the board signed on to the Cities for Climate Protection program developed by ICLEI--Local Governments for Sustainability, then conducted a GHG emissions analysis and set emissions-reduction goals.

A sustainability working group of local residents was convened to help prepare a set of guiding principles. The 12 principles form the basis for countywide goals that underlie all policies, programs, and implementation measures of the plan. These include items that explicitly address the need to change land use, development, and transportation patterns to slow the rate of climate change. Other principles relate to sustainability concerns such as healthy local food, protecting water resources, intact ecosystems, and well-designed, affordable housing built near transit nodes.

The countywide plan is organized around three elements: natural systems and agriculture, the built environment, and socioeconomics. Policies focus on reducing GHG emissions, monitoring climate change, and adapting to its effects. These goals are to be reached through such efforts as increasing use of renewable energy, developing green building and energy-efficiency programs, changing commuting and driving patterns, and reducing methane emissions from solid waste disposal. Adaptation measures include revision and implementation of floodplain ordinance, increased research on sea-level rise, and establishment of a climate change planning process.

A format of 4 questions is used to address each goal in the plan:

1. What are the desired outcomes?
2. Why is this important?
3. How will results be achieved?
4. How will success be measured?

Question 1 helps set targets while 3 and 4 are used to develop indicators and benchmarks to evaluate progress. Each section of the plan includes a program implementation table, which summarizes the responsibilities, potential funding priorities, and estimated time frames for proposed implementation programs.

Creative Funding: Some of the programs are partially funded because they are part of the ongoing operations of the county. Adding sustainability goals only required adjusting departmental or program operations. But funds were needed to incorporate those goals into the county's business practices. The county was able to use some money that had been set aside for updating the general plan by combining green strategy preparation with that plan. It also utilized existing staff and both paid and unpaid interns. Small increases in land use and permitting fees provide funds for the continuing task of reviewing proposed projects to ensure that green objectives are accomplished. Other implementation funds have come from grants, especially from utilities and state agencies concerned with waste management and energy, as well as some general fund and foundation monies. The federal Block Grant Program and Conservation Block Grant Program may provide future funds.

Funding Summary:

- Partial funding by incorporating into ongoing county operations
- Money previously set aside to update general plan
- Utilization of existing staff; paid and unpaid interns
- Increases in land use and permitting fees to create budget for monitoring
- Grants from utilities and state agencies (waste and energy management)
- General fund
- Foundations

American Planning Association. 2010. *Planning for a New Energy and Climate Future* pp. 50-51

Economic Analysis of Options (Fox-Wolf River Basin and Green Bay, WI)

In 1992, the Green Bay Municipal Sewer District was looking for ways to reduce water pollution without imposing high costs on area residents. It partnered with a new not-for-profit corporation called Northeastern Wisconsin Waters for Tomorrow (NEWWT) to search for cost-effective alternatives to conventional regulation in the watershed. NEWWT developed a computer simulation of the Fox-Wolf River Basin to help understand how the flow of water, nutrients, solids, and other materials affected the quality of the river and the bay. This data could then help in setting pollution control targets that would most effectively improve water quality. It could help determine where investment would have the greatest impact on cleaning up the water.

Phosphorous and suspended solids were particular problems in the Fox-Wolf River Basin, and the model showed that about 75 percent of the phosphorous and 90 percent of the suspended solids that reach lower Green Bay came from rural sources upstream. An economic analysis of control options determined that the cost of controlling the upstream sources would be significantly less than the cost of treatment downstream. It was estimated that it would cost $9.64 per pound to reduce phosphorous releases from agriculture compared with $165 per pound to reduce phosphorous in municipal water treatment facilities. Similarly, it would be $.008 (less than a penny) per pound to prevent suspended solids at the outlet of the watershed compared with $4.61 per pound at the treatment plant.

The lower cost option was clearly to reduce the amount of phosphorous and solids entering the waters from agricultural land. This could be achieved through planting vegetative buffers along river banks to minimize erosion, encouraging more efficient use of fertilizers and pesticides, setting up zoning and livestock exclusion ordinances to minimize animal access to streams, and improved management of animal wastes. The State DNR has pursued these goals through educational outreach programs directed at changing farming practices, providing technical assistance, and partially subsidizing the costs of new nonpoint source controls. The one major weakness of such a source-reduction process is that changing human behavior can be slow, whereas changing technology has a clearly defined timeframe.

White, David, Paul Baumgart, and Bruce Johnson, eds. 1995. "Toward a Cost-Effective Approach to Water Resource Management in the Fox-Wolf River Basin: A First Cut Analysis." Green Bay: Northeast Wisconsin Water of Tomorrow.

Public Participation (Green Bay, WI)

The Green Bay Remedial Action Plan provides an example of how public voices can be included in a planning process.

The Green Bay RAP is a set of recommendations and guidelines developed by the Wisconsin DNR in "partnership with local governments, other agencies, businesses, and many interest groups--agricultural, academic, environmental, conservation, and recreational--in the Fox-Wolf River Basin." (WDNR 1993) The WDNR began the process in 1985 when it set out to develop a plan for Green Bay, a designated Area of Concern. The resulting RAP, completed in 1987, became a model for others because it included citizen involvement, through a Citizens Advisory Committee (along with four technical advisory committees) and took an ecosystem approach to planning for water quality improvement. (Harris 1992)

The RAP includes a vision of the future based on an ecosystem view that seeks to restore ecosystem function. This includes return to a condition in which full beneficial uses of area waters are possible. The RAP relied on extensive modeling of the rivers and bay, along with ecological risk assessments, to determine how specific stressors affect water quality and aquatic life. It was also necessary to develop appropriate indicators of local ecosystem health in order to monitor the effects of any remedial actions undertaken. This was achieved by creating a "State of the Bay" scorecard that used indicators consistent with scientific investigations in area waters, yet could be understood by the "informed public" and decision makers, and therefore could be used in discussions about remedial activity. (Harris 1994)

This process produced a set of goals for long-term water quality that focused on social and economic conditions in the area as well as ecosystem health. The goals included: a healthy bay environment; a balanced, edible sport and commercial fishery; productive wildlife and plant communities; water-based recreational opportunities; good water quality that protects human health and wildlife; balanced shoreline uses; and an environmentally sound and economical transportation network. A 1993 update added the goal of ensuring "the sustainability of a restored and healthy environment through pollution prevention and the development of sustainable economies, resources, and facilities which support beneficial uses into the future" (WDNR 1993).

In developing this RAP, diverse interest groups worked together to define the problems and solutions. Then the public was included in the process for deciding how to meet these goals, so they too were part of the decision-making process. The RAP technical committees developed 120 detailed recommendations for achieving the objectives, then two public information meetings and a public hearing helped determine which of these should have greatest priority. Naturally, short-term and inexpensive projects such as voluntary reductions in phosphorous discharges and habitat rehabilitation were the first to be completed. But the RAP also succeeded in drawing attention to the problem of runoff pollution, which resulted in large-scale nonpoint source management projects in the basin that could only be accomplished with both public and private action. To facilitate this, the WDNR made cost-sharing funds available to help communities and landowners meet nonpoint source reduction goals. (Harris 1992, WDNR 1993)

Harris, Hallett J. 1994. *The State of the Bay, 1993: A Watershed Perspective*. Green Bay, WI: University of Wisconsin-Green Bay Institute for Land and Water Studies, August.

Harris, Victoria A. 1992. "From Plan to Action: The Green Bay Experience." In *Under Raps: Toward Grassroots Ecological Democracy in the Great Lakes Basin*, ed. John H. Hartig and Michael A. Zarull. Ann Arbor: University of Michigan Press. Pp. 37-58.

Wisconsin Department of Natural Resources. 1993. *Lower Green Bay Remedial Action Plan 1993 Update for the Lower Green Bay and Fox Area of Concern*. Madison: WDNR, September.

ECOLOGICAL RESILIENCY

Regional Collaboration (Saginaw Bay, Michigan) [1]
Saginaw Bay Greenways Collaborative

Overview
The Saginaw Bay Greenways Collaborative (the Collaborative) represents a group of local, state, and federal agencies, nonprofit organizations, and concerned citizens united around the goal of developing a green infrastructure system in Saginaw, Bay, and Midland counties in Michigan. Various members of the Collaborative are motivated by interests in wildlife, water quality, non-motorized transportation, recreation, urban and land-use planning, tourism, and economic development. The planning work, which included an extensive public and local government involvement component, was funded primarily by the Saginaw Bay Watershed Initiative Network.

The Saginaw Bay Greenways Collaborative created a vision for a green infrastructure network by using a scientific and community participation approach to identify land best suited for conservation and recreation in Saginaw, Bay, and Midland counties. The Collaborative identified and mapped important green infrastructure elements (hubs, cores, and corridors) across the tri-county region (Figure 1) and is making this information available to municipal leaders and decision makers to include in pertinent land use plans at all scales and jurisdictions.

The Collaborative based the planning process on three key elements of successful greenway and green infrastructure initiatives:

- A thorough resource inventory and analysis of the project area, based on the most accurate and current resource information available,
- Public involvement in the development of a green infrastructure plan, and
- Development and distribution of information to the public on the project and the benefits of greenways and green infrastructure.

In their summary report, which was released in early 2005, the Collaborative recommended an implementation strategy that addresses organizational development and possible funding mechanisms and identified a range of tools and resources available to help communities and the region conserve, protect, and restore the green infrastructure network.

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[1] This text is the first page of The Conservation Fund's case study on the Saginaw Bay Greenways Collaborative. The Conservation Fund Green Infrastructure Case Series http://www.greeninfrastructure.net/sites/greeninfrastructure.net/files/4-FINALSag%20Bay%2007.18.05.pdf

Public and Private Cooperation (Northwest Lower Michigan)

Conservation Resource Alliance's Wild Link and River Care Programs, Northwest Lower Michigan[2]

Overview

The Conservation Resource Alliance (CRA) was established in 1968 to work on regional watershed protection. CRA has been extremely successful in building a grassroots network of local support for on- the-ground conservation action at all levels, from individual landowners and citizens to local, state, and federal governmental agencies and many of the large corporations and foundations in the Great Lakes region and around the country.

According to CRA director Amy Beyer, the organization is "working parcel to parcel to change the way landowners interact with the land. We're not trying to stop land from changing hands or being developed." She believes that private landowners may be the most important component in addressing the future ecological health of northwest lower Michigan. The organization's overarching goal is to raise the regional IQ on ecosystem issues and teach people that how they manage their land matters.

Because of CRA's long-term commitment to region- wide ecosystem protection, they were a natural partner when in 1995 The Conservation Fund and the National Park Service's Rivers, Trails, and Conservation Assistance Program (RTCA) became interested in applying the concepts of greenways and green infrastructure in northwest lower Michigan. CRA worked with the Fund, RTCA, and local and regional government agencies and private groups to develop a plan for greenways protection in the region. From the start, CRA was most interested in the ecological side of greenways—the green infrastructure side—while other groups concentrated on the recreational side. RTCA provided technical assistance to coalesce various greenways efforts that were already underway in the region.

The vision for the Northwest Michigan Greenways project was to "identify and promote a system of ecological and recreational linkages to protect and enhance the natural beauty and integrity of northwest lower Michigan." Steps taken to achieve this vision included:

- collecting input from citizens, government agencies, and experts on the desired characteristics of a greenways system;
- identifying and mapping important ecological corridors and trails;
- maintaining an inventory of existing greenways resources;/"
- encouraging intergovernmental coordination of recreation, transportation, and land-use plans;
- focusing support for local greenways initiatives through public education; and
- identifying methods for funding local greenways projects.

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[2] This text is the Overview section of The Conservation Fund's case study report on the Conservation Resource Alliance. The Conservation Fund, Green Infrastructure Case Study Series http://www.greeninfrastructure.net/sites/greeninfrastructure.net/files/5-CRA%2008.30.05_0.pdf

Now, a decade later, CRA has identified and mapped important ecological corridors in the area's seven fastest growing counties. CRA uses this information to prioritize work on its two main programs, Wild Link and River Care, where it is most urgently needed. Wild Link, which CRA started in 1998, is a voluntary program that assists private landowners in managing corridors on their property that wildlife may use to travel from one large parcel of land, such as a state forest, to another. The impetus behind the program is simple. "Every time a rural property is subdivided and developed, we potentially break wildlife connections, and the habitat fragments that are left are not enough to sustain important populations," says Jeff Breuker, CRA wildlife biologist. "The idea is to provide interested landowners with technical assistance and the know- how to manage their lands and to ensure that they are usable by wildlife for food, water, breeding, and travel needs. If we can get neighboring landowners interested in 'linking' all these lands together, we will ensure wildlife habitat for years to come."

River Care is a watershed-based program through which CRA leverages financial and in-kind support to perform on-the-ground habitat improvement and restoration projects on a number of world-class trout streams in northwest lower Michigan. The goal of River Care is to "empower local river restoration groups with technical and financial support to carry out priority conservation projects, and to build local partnerships on rivers where none exist." Already, CRA has coordinated a multitude of partners in completing the stabilization and restoration of more than 400 degraded stream and river banks, nearly 100 severely impacted road crossings, and a number of degraded recreational access, agricultural, and residential sites. Like Wild Link, River Care work focuses along pre-identified ecological corridors.

CRA's Wild Link, River Care, and greenways activities contribute to protecting and restoring important ecological and recreational connections in northwest lower Michigan for the benefit of the environment, wildlife, and local citizens. These programs provide an innovative model of strategic conservation actions undertaken cooperatively with the owners of private lands important to the ecological health of CRA's focus area and to the connectivity of large protected conservation lands in that area.

Long-term Implementation Through Public Participation

Krantzberg, Gail. "Sustaining the Gains Made in Ecological Restoration: Case Study Collingwood Harbour, Ontario." *Environment, Development and Sustainability* (2006) 8: 413–424

Abstract:
As part of the commitments made by the governments of Canada and the United States in the Great Lakes Water Quality Agreement, Remedial Action Plans (RAPs) are being developed and implemented at Great Lakes Areas of Concern. The Areas of Concern are specific places around the Great Lakes basin ecosystem where environmental quality is degraded to the point that certain beneficial uses (the ability of fish, wildlife and humans to thrive) are impaired. According to the United States and Canada Great Lakes Water Quality Agreement of 1987, the federal governments, in cooperation with state and provincial governments, are to ensure the public is consulted throughout the development and implementation of the RAPs. While not explicit in the Agreement, it is logical to posit that given the effort and investment in environmental improvements, community capacity to sustain the recovery of beneficial uses beyond the life of the RAP should be a product of the RAP. This report examines a case study to test the hypothesis that public ownership of the RAP process can result in the development of community capacity to sustain environmental recovery. The question is, were the principles of the RAP, 10 years after delisting, taken into account to ensure sustainability of growth along the waterfront and within the Town? To arrive at the answer it is important to explore the approach used in the Collingwood Harbour RAP process, and concepts and principles of sustainable cities and towns. This paper provides evidence that such principles are being applied in Collingwood and were nurtured during the development and implementation of the RAP.

Keywords community stewardship - environmental restoration - Great Lakes protection - remedial action plans - sustainable communities

Planning Process:
Developing the Adaptation Strategy

1. Set Goals

Examples of potential goals include:

- Monitor and maintain functioning and healthy coastal ecosystems.
- Reduce the costs associated with disaster response and recovery.
- Protect critical facilities and infrastructure from the impacts of climate change.
- Minimize economic losses attributable to the impacts of climate change.
- Increase public awareness about climate change and how it may affect the coast.
- Reduce the impact of climatic and nonclimatic stressors on natural systems.
- Increase and improve technical capacity to assess and address impacts of climate change.
- Provide leadership and support to local governments for climate change adaptation planning.

2. Identify Actions

Research adaptation measures that address the impacts you have identified. Consider plans on hazard mitigation, emergency operations, environmental preservation, economic development, resource management, transportation, etc, as sources of ideas for actions connected to existing programs.

3. Evaluate, Select, and Prioritize Actions

Metrics to consider in order to evaluate actions:

- How well the action meets your goals
- How urgent the need is for implementation of the action
- How easy the action is to implement
- If funding is readily available for implementation
- If the action meets multiple objectives (maximizes benefits)
- If the action also helps mitigate climate change
- How reliable the projections the action is based on are
- How flexible the action can be under a range of climate change scenarios

4. Formalize the Adaptation Plan

Once you have selected the appropriate actions, it is highly recommended that you put together brief action plans for EACH individual action.

Adapting to Climate Change: A Planning Guide for State Coastal Managers. National Oceanic and Atmospheric Administration, 2010

Potential Planning Team Members

The following is a list of entities from which you may want to recruit potential climate change adaptation planning team members. Some of these entities listed below may serve the team better in a supporting role (e.g., providing resources) rather than in a decision-making role as a team member.

State Agencies/Departments

Environment and Agriculture

- Agriculture
- Coastal Management
- Environmental Protection
- Fish and Wildlife
- Forestry
- Geological Survey
- Marine Resources
- Natural Resources
- Parks and Recreation
- State Climatologist

Planning and Public Safety

- Building Code
- Emergency Management
- Fire
- Flood Control
- Hazard Mitigation
- Homeland Security
- Local Affairs
- National Guard
- Planning
- Public Health

Housing and Infrastructure

- Energy
- Engineering
- Housing
- Public Works
- Stormwater Management
- Transportation
- Utilities
- Water Resources

Economic Development

- Commerce
- Economic Development
- Insurance

Other

- Education
- Historic Preservation
- Tourism
- Universities/research institutions
- (including Sea Grant programs and Assessment programs)

Potential Planning Team Members

Other potential sources for planning team members and supporters include:

- Regional organizations/programs (e.g., regional ocean governance bodies)
- Elected officials
- Local governments, coastal programs in particular
- Regional planning organizations
- Native American tribal organizations
- Nonprofit organizations and associations (e.g., land trusts and environmental organizations, such as the Nature Conservancy and the National Wildlife Federation; associations of state floodplain and wetlands managers, etc.)
- Neighboring states
- Other research institutions Infrastructure managers (see definition in Chapter 4) Industries (tourism, fisheries, oil and gas, shipping, etc.)
- Contractors/engineers
- Developers
- General public

Potential Planning Team Members

Federal Agencies/Departments

US Department of Commerce

- Economic Development Administration
- National Oceanic and Atmospheric Administration
  - National Environmental Satellite, Data, and Info Service
  - National Marine Fisheries Service
  - National Ocean Service
  - National Weather Service
  - Office of Oceanic and Atmospheric Research

U.S. Department of Agriculture

- Animal Health and Plant Health
- Inspection Service
- National Institute of Food and Agriculture
- National Resources Conservation Service
- U.S. Forest Service

U.S. Department of Defense

- U.S. Army
- U.S. Army Corps of Engineers
- U.S. Air Force
- U.S. Marine Corps
- U.S. Navy

U.S. Department of Energy

- Office of Electricity Delivery and Energy Reliability

U.S. Department of Homeland Security

- Federal Emergency Management Agency
- U.S. Coast Guard

U.S. Department of the Interior

- Bureau of Indian Affairs
- Bureau of Water Reclamation
- National Parks Service
- U.S. Bureau of Land Management
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

U.S. Department of Housing and Urban Development

- Community Planning and Development
- Housing
- Public and Indian Housing

U.S. Department of Transportation

- Federal Highway Administration
- Pipeline and Hazardous Materials Safety Administration

U.S. Environmental Protection Agency

- Office of Air and Radiation
- Office of Policy, Economics, and Innovation
- Office of Water

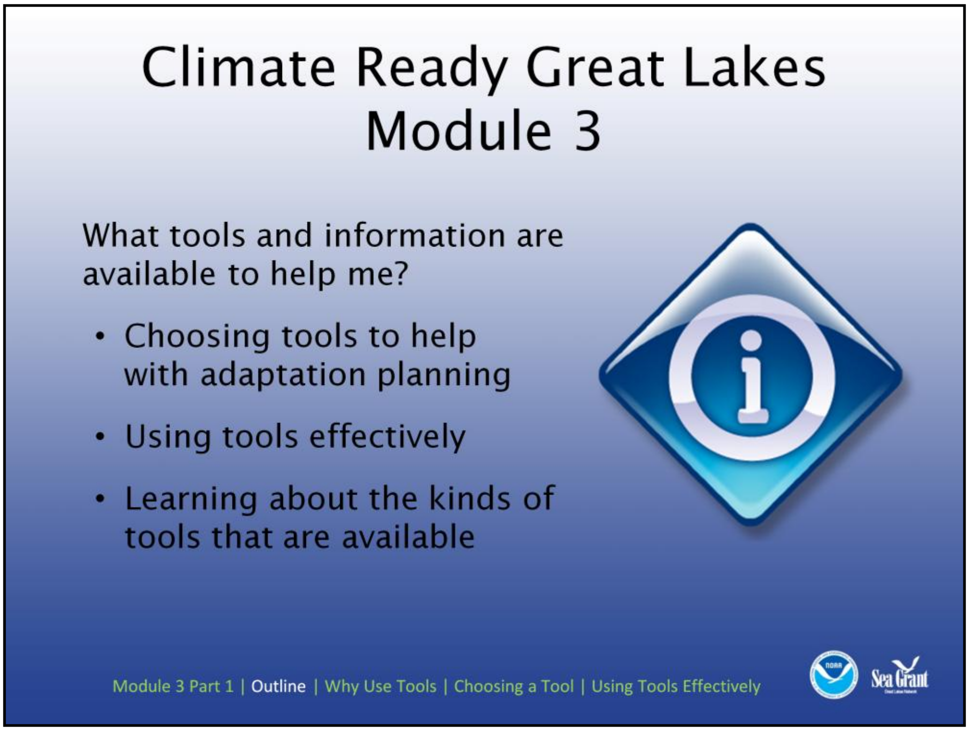

Climate Ready
Great Lakes
NOAA
Sea Grant
Great Lakes Network

Climate Ready Great Lakes

Great Lakes Climate Change Module 3

Climate Change Adaptation Tools Available to Great Lakes Communities as of January 1, 2011

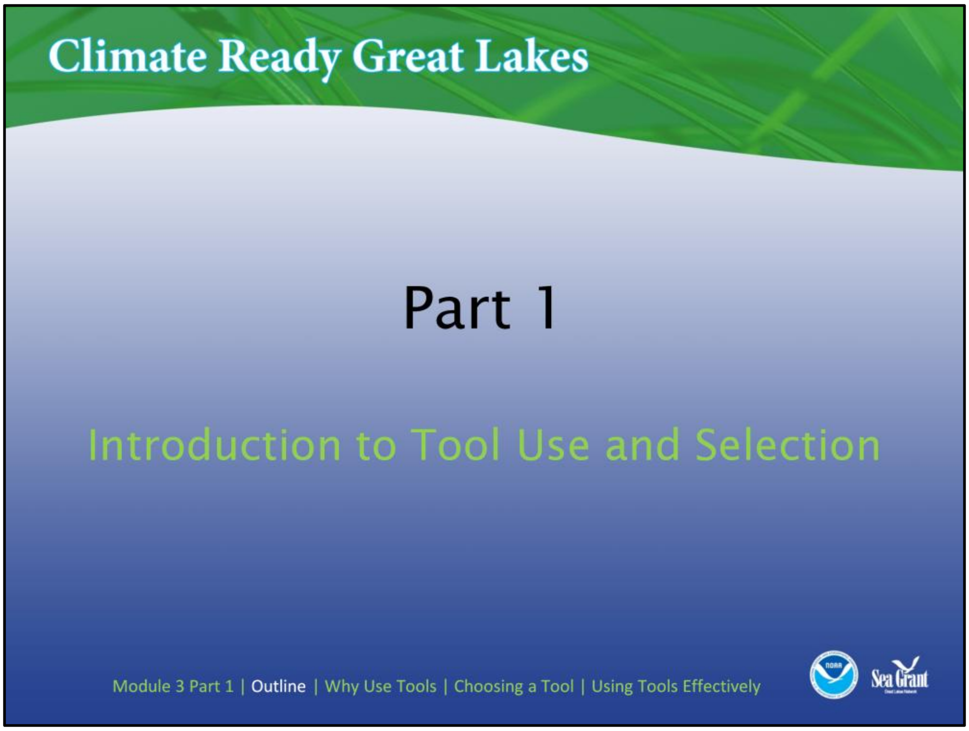
Climate Ready Great Lakes is a series of three related—but standalone—modules designed to assist Great Lakes coastal communities in preparing for possible effects of climate change. Module 1 introduces participants to predicted climate change impacts in the Great Lakes region. Module 2 guides participants through creating an adaptation plan, and this module—Module 3—helps participants effectively use tools in the adaptation planning process.



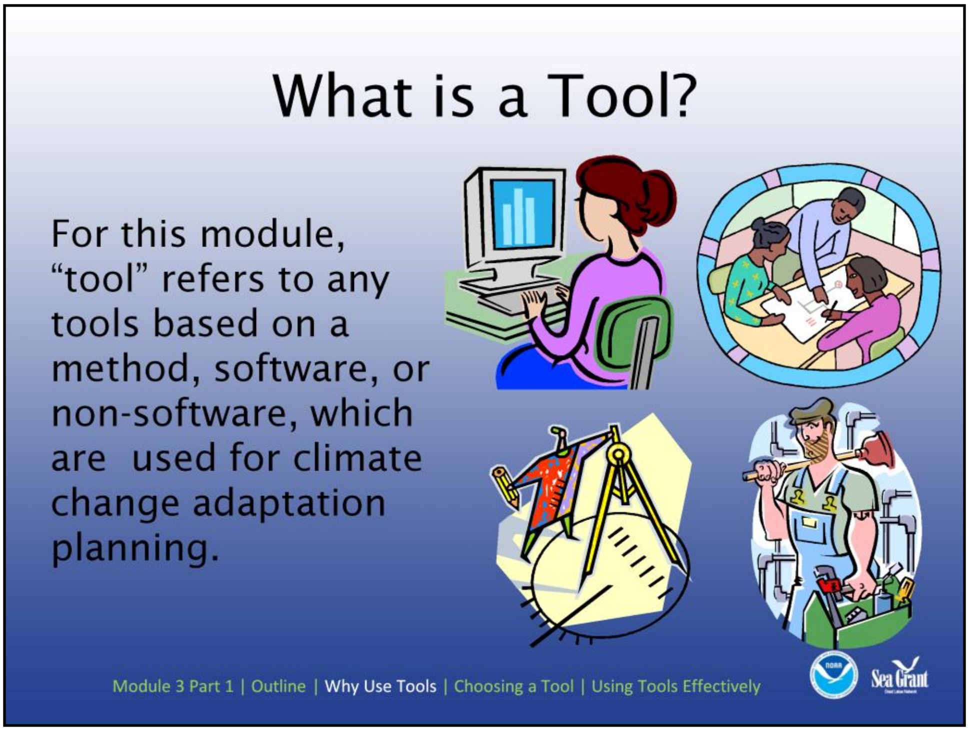
This module highlights tools that are available for climate change adaptation planning.

- Some tools are specifically made for the Great Lakes region, while others can be modified to fit the region.
- The tools vary in terms of complexity and required resources.
- Most are software tools—but some are web- and process-based.

This module is broken into two parts: Part 1 will introduce you to effective tool use and selection. Part 2 will introduce you to the various types of tools that are available to help communities with adaptation planning.



Tools are an important resource for adaptation planning. Part 1 teaches you how to select tools appropriate for your needs and how to effectively use tools and related resources.



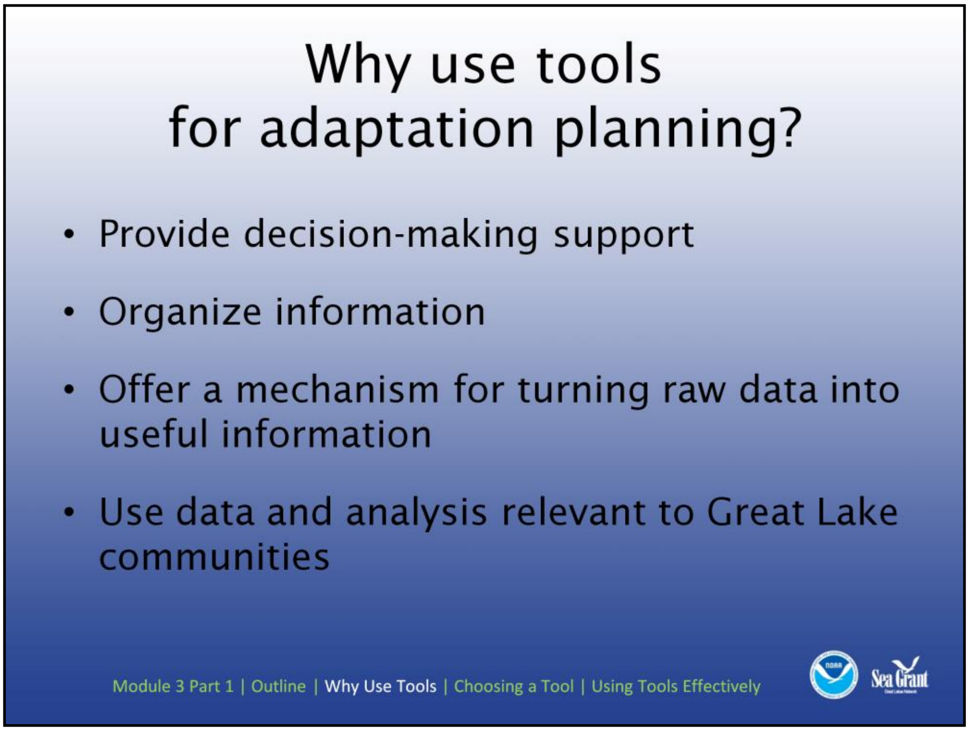
First, it is important to clarify what we mean by the word “tool.” In this module, “tool” can indicate any of the following:

- Method-based tools outline a process for users to follow in order to achieve a goal—or carry out an analysis (among other applications).
- Software-based tools require users to download or install software in order to run the tool on a computer.
- Non-software-based tools are tools that do not fit either category. These are non-method tools that are computer based or non-computerbased. So for example, this category could be applied to a computer database that offers users information on climate change tools.

Note: This module tends to emphasize computer- and technology-based tools from each category; however, it is important to realize that tools can also be non-computer based (such as survey methods outlined in a book).

Source citation:

Ecosystem-Based Management Tools. 2010.“Ecosystem-Based Management Tool Inventory.”



Tools are important in adaptation planning, because they can

- Provide guidance and support for decision makers
- Help to organize ideas for planning and to get adaptation plans started.
- Help turn raw data into useful, organized information.

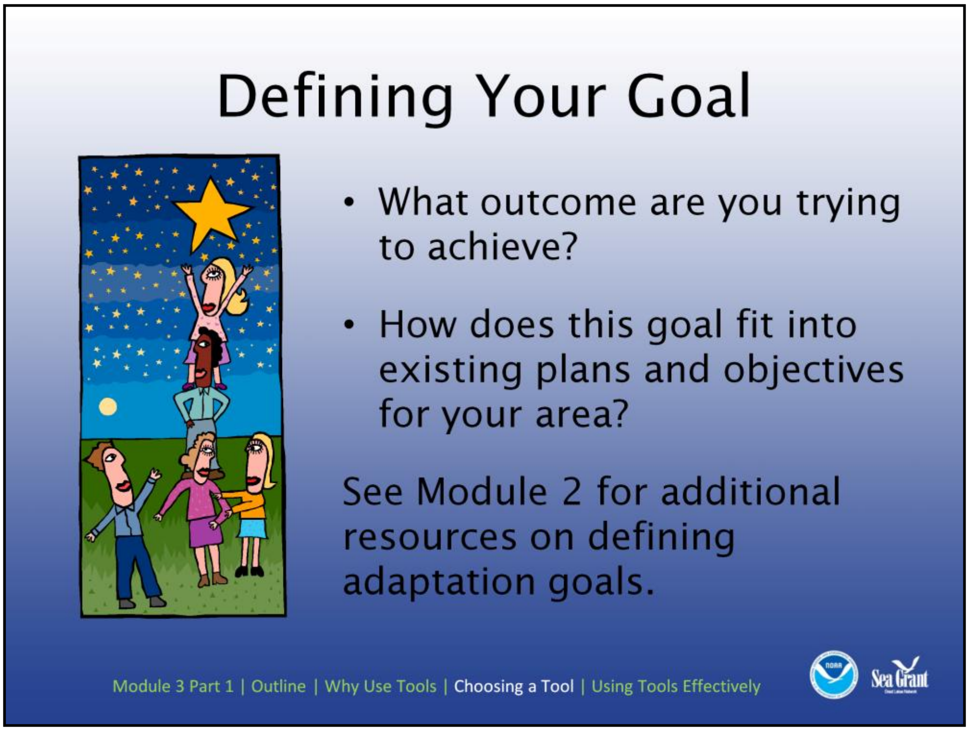
Unfortunately, adaptation planning is often limited by available tools—but new tools are often under development. This module does not provide a comprehensive review of all tools. Instead, this module is intended as a method to (1)introduce users to tool use in climate change adaptation planning and (2) serve as a starting point for locating tools for adaptation planning. This module focuses particularly on tools relevant—and available—to Great Lakes coastal cities.

Source citation:
National Oceanic and Atmospheric Administration,Office of Ocean and Coastal Resource Management. "Adapting to Climate Change: A Planning Guide for State Coastal Managers." http://coastalmanagement.noaa.gov/climate/adaptation.html (accessed December 28, 2010)

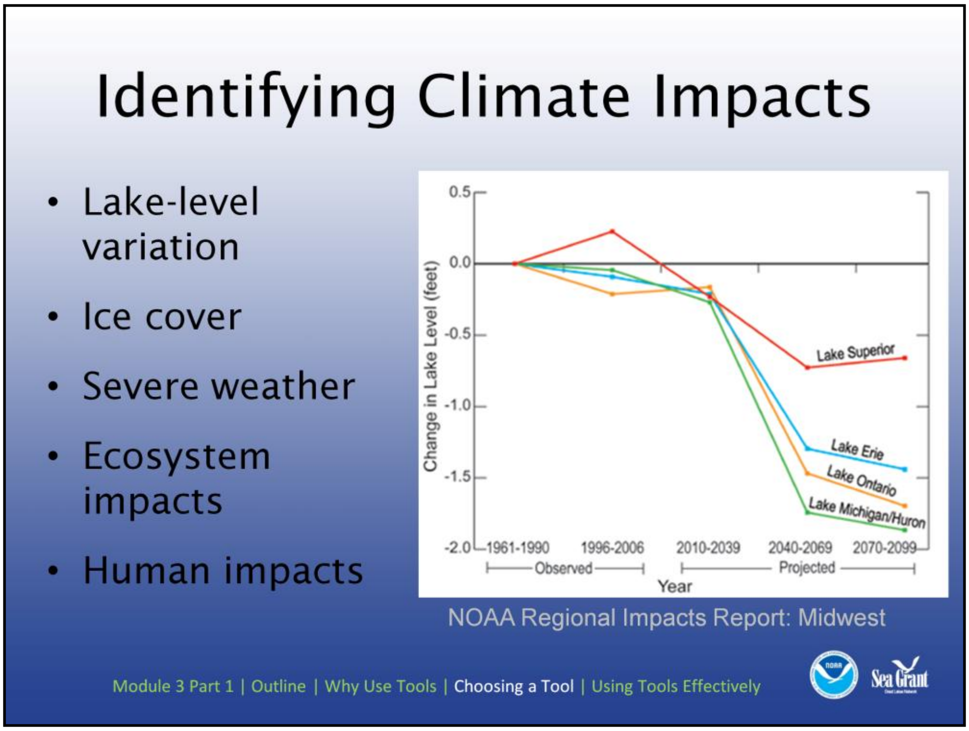
Now that we have gone over the importance of tools, we will outline how to choose a tool that fits the needs of your community. Choosing an appropriate tool can be challenging. Some tools address specific climate impact challenges, while others may not meet exact specifications.

The main questions you should be exploring are:

1. What is the goal you are trying to achieve?
2. Which climate change impacts are you trying to adapt to?
3. What resources do you have available? For example,personnel, financial assistance, or technical expertise.
4. How does the project fit into larger planning goals in your community?
5. Where are help resources (such as expert consultation)?



The most important step in choosing an appropriate tool is clearly outlining the purpose of your project. It is important to clearly define your goal and objectives in order to select the most effective tool. Before starting your project, it is also important to do some research and find out what current plans and projects exist in your area.



To pick a tool, it is important to identify which climate impact(s) you are adapting to. There are a variety of anticipated impacts in the Great Lakes region, and each adaptation planning project should identify both desirable and undesirable impacts for planning purposes. Later, we will discuss how to match the impact with the tool.

Image citation:

National Oceanic and Atmospheric Administration. 2009. "Global Climate Change Impacts in the United States: Midwest." http://www.globalchange.gov/images/cir/pdf/midwest.pdf

- Learn from what others have done. It is important to review case studies and best practices, when available. Your state climatologist is one resource who may be able to help identify best practices and tools. There will be more information in the "Education, Training, and Support" section of this module.
- Research possible funding opportunities. What funders are interested in your project? Consider federal, state, and local funders.
- Consider internal and external partnerships to help with funding and staffing needs.
- Find existing data, if possible. Several data websites are listed in this module to assist you in finding available data, and hopefully those will meet your needs. If not, ask for help. Collecting data on your own can be quite expensive.

When it comes to selecting a tool, the bottom line may be finding a tool that fits the resources you have available. Each tool has its own requirements, but keep in mind that some tools have extensive requirements for technological expertise, funding, and staffing. If the tool you are considering is technologically advanced or requires the use of GIS, know that you may need to hire a staff member or outsource part of the project.

Source citation:
National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management. 2010. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. http://coastalmanagement.noaa.gov/climate/adaptation.html

Handout:
Tool/Impact Spreadsheet

CLIMATE IMPACTS	Stormwater Management	Flood Hazard Reduction	Drought	Building/ City Infrastructure	Shoreline Infrastructure	Transportation	Energy	UHI/Human Health	Air a Wat Qual
TOOL NAME									
Building Coast-Smart Communities: A Role Play Exercise	X	X	X	X	X	X	X	X	X
Environmental Planning for Small Communities (TRILOGY)	X	X	X	X	X	X	X	X	X
Green Communities	X	X	X	X	X	X	X	X	X
CAKE	X	X	X	X	X	X	X	X	X
Coastal Inundation Toolkit	X	X		X	X				
Coastal Services Center Modules	X	X	X	X	X	X	X	X	X
EBM	X	X	X	X	X	X	X	X	X
Great Lakes Weather and Climate	X	X	X						
National Estuarine Research Reserve Training	X	X	X	X	X			X	X
Sea Grant Training: Ohio State University Webinars									X
Coastal County Snapshots		X							
GLIN	X	X	X	X	X	X	X	X	X
Historical Maps and Charts	X	X	X	X	X	X	X	X	X
MyEnvironment								X	X
NOAA Digital Coast	X	X	X	X	X	X	X	X	X
NOS Data Explorer	X	X	X		X				
BASINS	X	X	X						X
CITYgreen	X	X		X			X	X	X
Coastal Ecosystem Restoration									
CVAT	X	X		X				X	X
FEMA HAZUS		X		X					
Habitat Priority Planner				X					
i-Tree v3.0	X	X		X					X
Impervious Surface Analysis Tool	X	X							X
NatureServe Vista				X		X	X		
Lake Superior Duluth Streams.org	X	X							X
NatureServe Website									
NOAA Coastal Climate Adaptation	X	X	X	X	X	X	X	X	X
NOAA Coastal Service How-to-Guide	X	X	X	X	X	X	X	X	X
NOAA Climate Services Portal	X	X	X	X	X	X	X	X	X
NOAA State of the Coast				X	X				X
CanVis	X	X	X	X	X	X	X	X	X
Climate Wizard	X	X	X	X	X	X	X	X	X
Visualizing Coastal Erosion					X				

Next, refer to the tool/impact spreadsheet. Use this spreadsheet to cross-reference climate impacts with various tools. The tool categories were selected by experts to be the most useful in climate adaptation in the Great Lakes. Categories include analysis, community outreach, data, forecast models, training, and visualization. You may want to select several tools from different categories to reach your objectives. Different tools can be particularly useful at different points in the process.For example, CanVis (a visualization tool) is useful for every type of climate impact and is particularly helpful for engaging stakeholders.

The tool description handout describes each tool in more detail.

NOTE: At this time, the presenter should distribute the Tool Impact Spreadsheet and the Tool Description Handout to participants

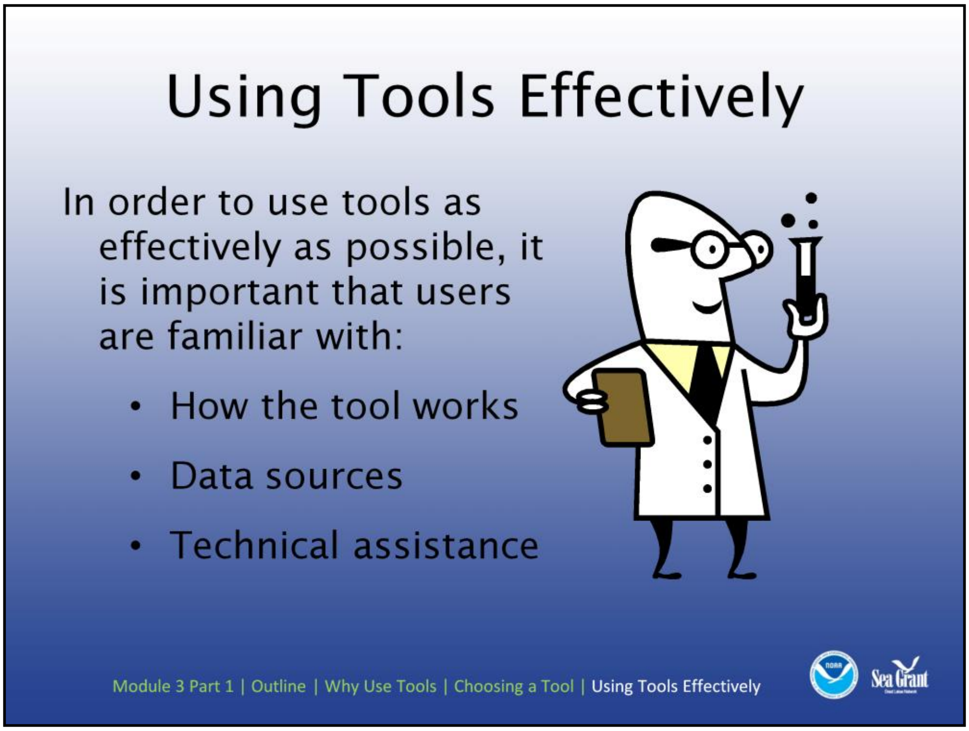
Tool Description Handout

The handout provides a more detailed description of each tool and is categorized according to types of tools.

- **Description:** Coastal County Snapshots is an interactive, web-based tool that allows users to access floodplain and flood zone information for their area. Once the tool is launched, users click on a U.S. state, and then click on their county, if available. Then, users have access to county demographics within the floodplain, including population, infrastructure, and environment. http://www.csc.noaa.gov/digitalcoast/tools/snapshots
- **Cost:** None
- **Training/Time Requirements:** None
- **Other Requirements/Notes:** None

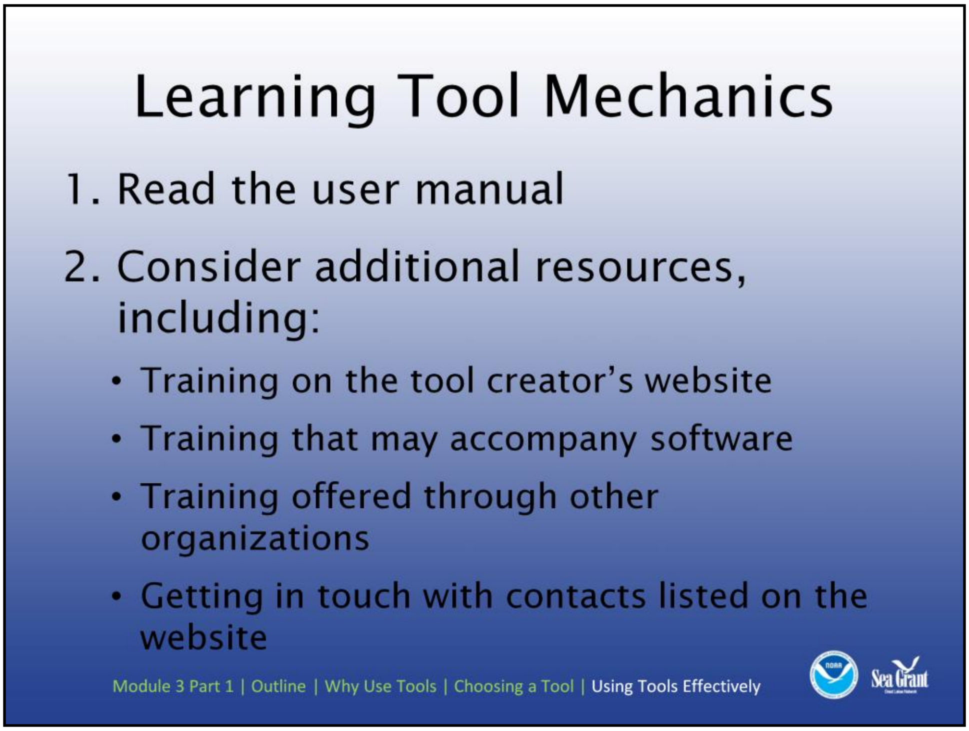
In the tool description handout, the information for each tool includes a link, description, keywords, cost, training/time requirements, and other notes. The training and time requirements indicate formal training and time to learn the tool. Some tools may require tinkering and time to become familiar with the interface.

(*Take a moment and go over process of selecting a tool.)*



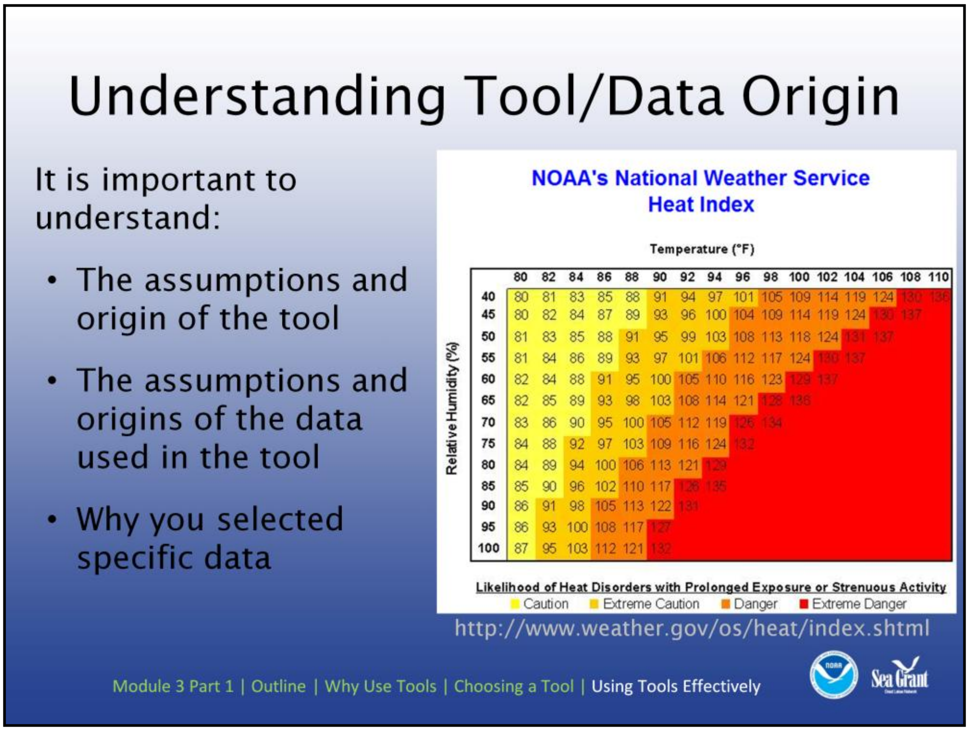
When you are using a new tool, sometimes it can be difficult to know where to start. It is important to break down the process, so that you are using the tool the way it was meant to be used. In the following slides, we break down the process of using a tool effectively into three steps:

1. Knowing the mechanics behind how a tools works
2. Understanding where data sources exist
3. Using available resources for technical support/assistance



Reading the accompanying user manual is always a good first step in learning (1)how a tool works and (2) how to best operate the tool. However, there are plenty of resources outside of a user manual that you can utilize in order to better understand tool mechanics:

- Look on the tool provider's website to see if they offer in-person or online training.
- Perform an online search to see if any other organizations (besides the developer) provide trainings (for example, EBM tools).
- Get in touch with the contacts listed on the tool provider's website. Often, they can suggest additional trainings, offer advice on how to use the tool, or answer questions about the tool.



Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

When it comes to using tools, it is important to be aware of what assumptions the tool relies on and where the data in the tool came from. When you are generating output, it will be important to explain to others where this output came from.

Read the user manual to get familiar with the tool's assumptions and the origins of the data and the tool itself—or ask the contacts listed on the tool provider's website. This type of information may not be available for every tool, but it is important to try to research this information. Similarly, if you're using your own data in the tool, you should be ready to explain to others where the data came from, the date it was produced, and other important details.

Image citation:
NOAA's National Weather Service, Office of Climate, Water, and Weather services. "Heat: A Major Killer." http://www.weather.gov/os/heat/index.shtml (accessed December 21, 2010)

Technical professionals are some of the best resources available to help you effectively use tools. These experts are often the contacts listed on tool provider's websites. They are extremely knowledgeable about the tool, and they may be able to refer you to training opportunities, help you with problems that you encounter in your use of the tool, and provide other references to assist you with your project. These types of contacts are usually only experts on a specific tool, but there are other types of contacts that can assist you in using tools more broadly.

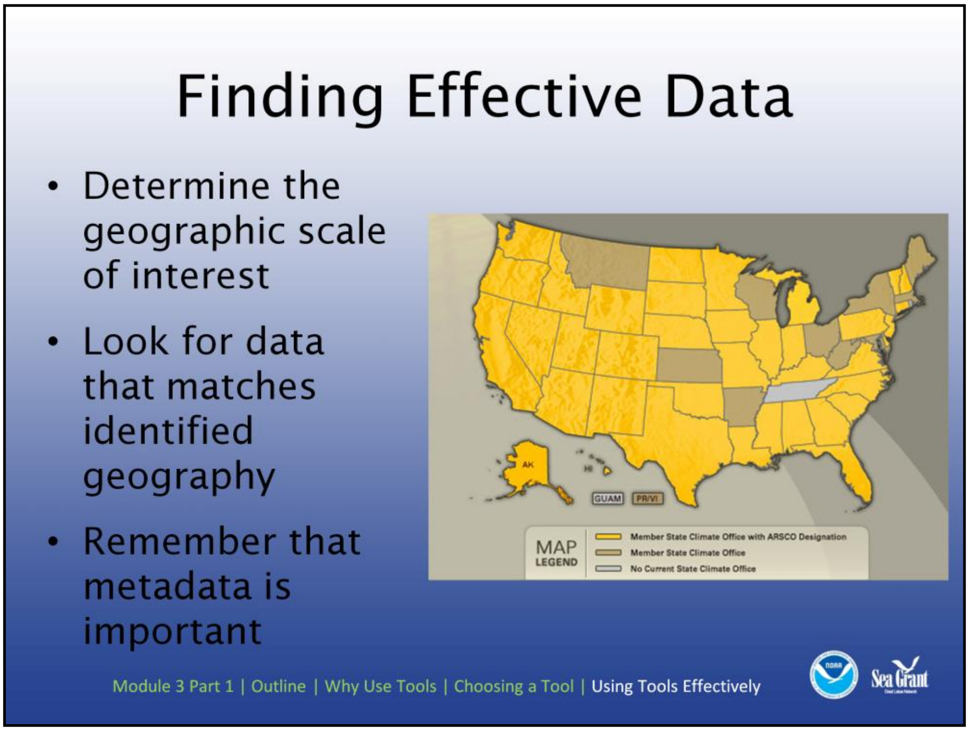
For example, state/regional climatologists may not be able to help you with the technical specifics of a tool, but they can act as an expert resource for the overall project. They can help you:

- Find data that is appropriate for your tool or project
- Determine whether or not your project will be a feasible one
- Identify potential future partners and resources
- Direct you to work and projects that are similar to your own

Please see the handout for a list of state and regional climatologists and their office websites.

Source citation:
Indiana State Climate Office, Purdue University. "ICLIMATE.ORG." http://www.stateclimate.org/ (accessed December 21, 2010)

Image citation:
Indiana State Climate Office, Purdue University. "ICLIMATE.ORG." http://iclimate.org/ (accessed December 21, 2010)



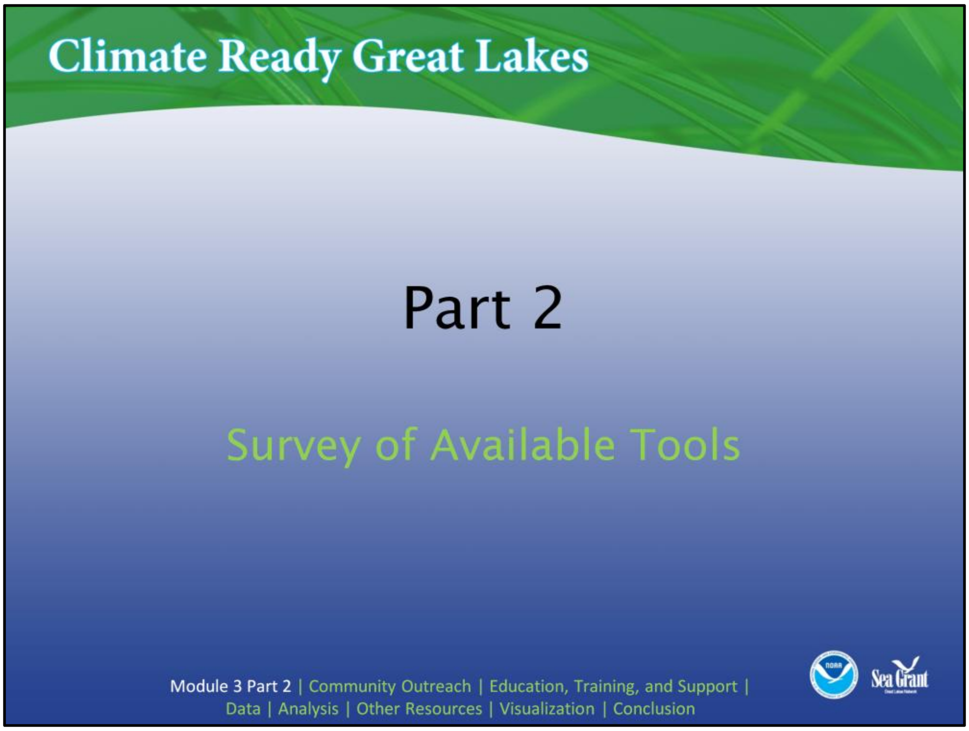
As was mentioned previously, some tools require users to generate their own data. This can range from providing your own data on climate change predictions (for an image creating program) to uploading your own shapefiles (for a GIS platform).

If you need to find your own data, first define the geographic scale of interest for your project (that is, regional, state, or local). Once you've determined the scale, then you should find data that fits this scope to ensure that the output is as specific to your area as possible.Local data provides the most specific information for community decision-making purposes.

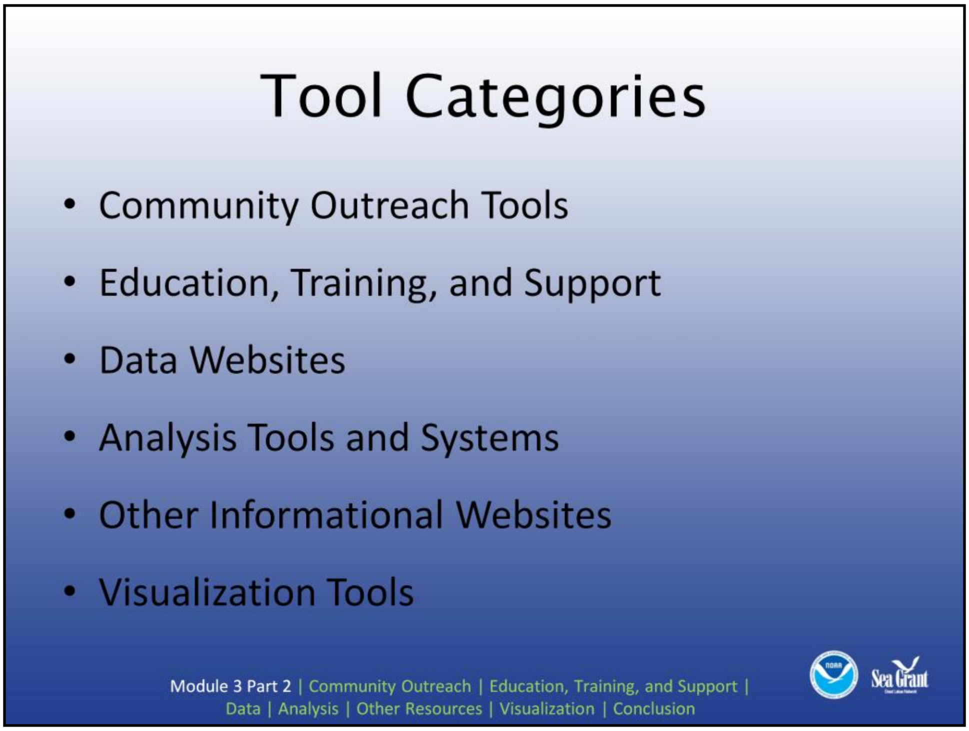
Also, remember that metadata (that is, data about the data) is important; you will need to convey information on the data background to the viewers. Examples of metadata include the data source, method by which the data was obtained, and the caveats associated with datasets. If there is a report or a visual display accompanying your output, be sure to specify the origin of the data in your materials.

In the context of climate data, it's important to look not only at recent patterns, but also to consider long timeframes of historical data.Understanding past climate is the first step in predicting how climate will change in the future.

Image citation:
American Association of State Climatologists. "AASC."
http://www.stateclimate.org/ (accessed December 21, 2010)



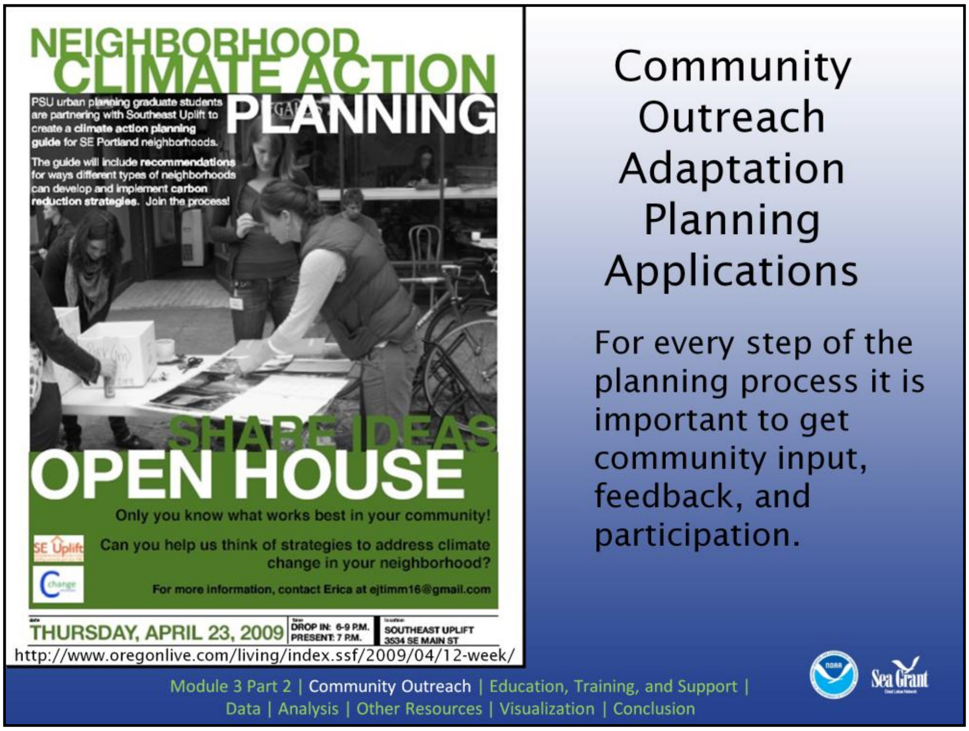
Part 2 of this module focuses on showcasing examples of tools that are available to assist communities in adaptation planning efforts.



In this module, tools are divided into six main categories based on their structure and the types of services they provide. For each category, we will first explain how the category can be applied to adaptation planning in general, and then give an example of a tool that fits in that category. Next, the specific adaptation planning applications for each tool will be discussed, and case studies will presented where available. To learn more about each category of tools (including example tools within each category), please see the supplementary tool description handout.

Source citation:
Laurentian Great Lakes Basin Climate Change Adaptation, Needs Assessment Synthesis. July 2010. (Mini-grant needs assessment.)

Community Outreach tools can assist decision makers in communicating with members of the community—ranging from the public to other decision makers in the community.



While community outreach tools are applicable in various stages of climate change adaptation planning, they are especially important at the beginning of the planning process (that is, Part 1, Step 1 for participants who have taken Module 2).

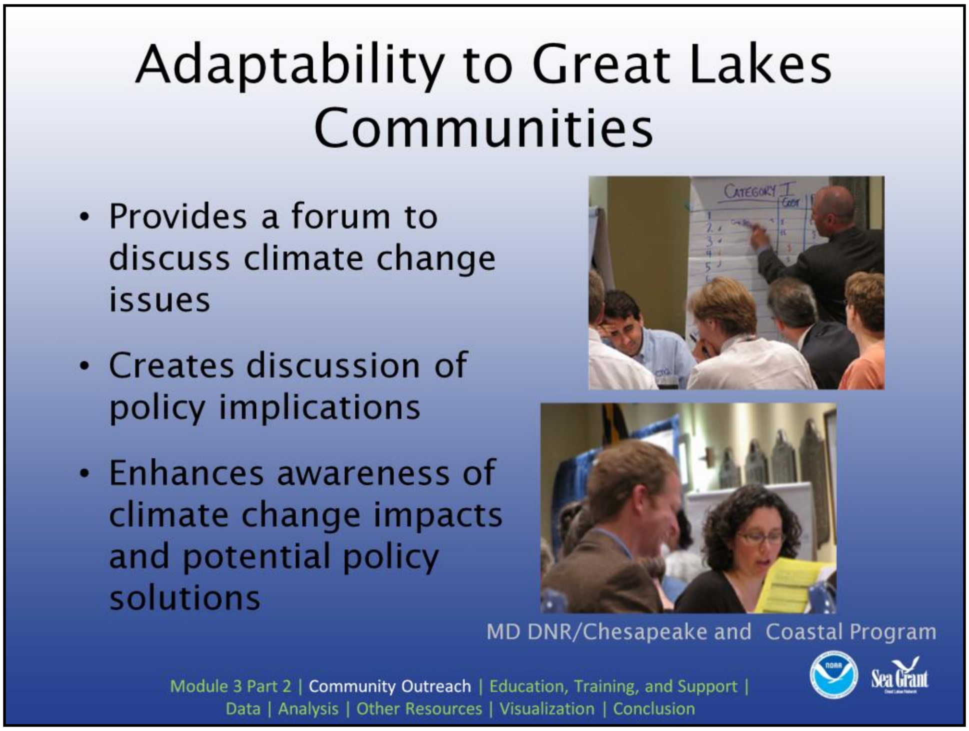
Community outreach tools can be used to get the public involved in the climate change adaptation planning process, inform them of climate and planning issues, and acquaint them with the complexities of climate change adaptation.

Image citation:
The Oregonian. “OregonLive.com.”
http://www.oregonlive.com/living/index.ssf/2009/04/12-week/
(accessed December 21, 2010)

An example of a community outreach tool is a role-play exercise called "Building Coast-Smart Communities."

Image citation:
Maryland Department of Natural Resources, Consensus Building Institute, MIT-USGS. 2009. "Building Coast-Smart Communities: A Role Play Exercise." http://maryland.coastsmart.org/ (accessed November 15, 2010)

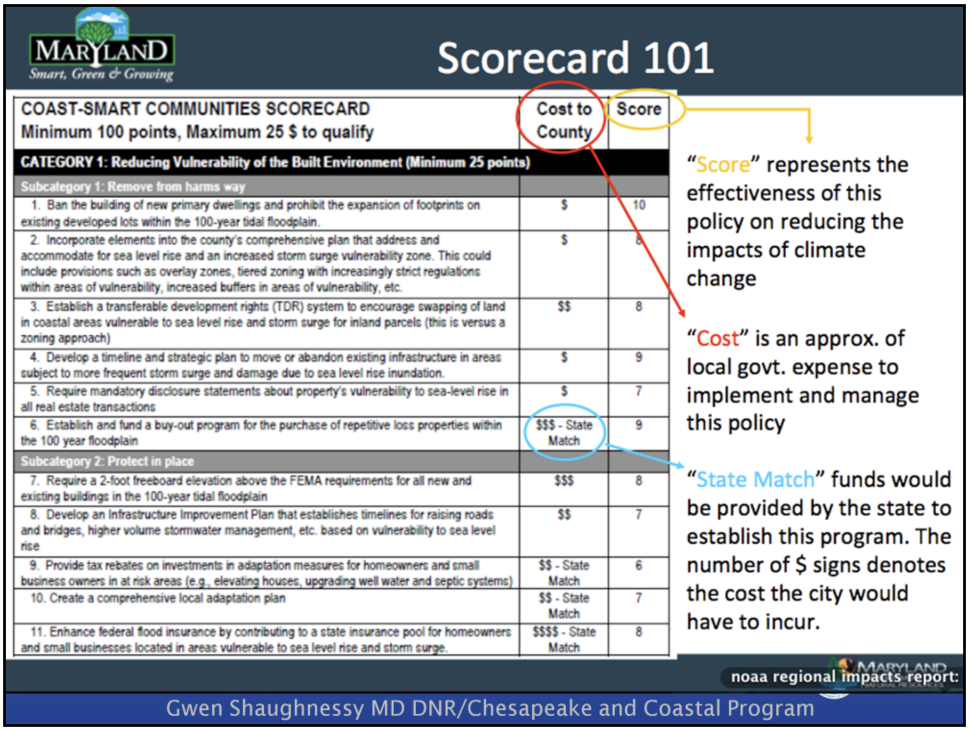
This tool is a half-day, role-play exercise that helps initiate community-based discussions about (1) climate change adaptation options and (2) the challenges associated with climate change (mainly focused on policy). There is no cost for the workshop; however, participants would need to commit to a half-day workshop and extensive advancedworkshop preparation may be required.



This exercise was specifically made for Maryland; however, it can be adapted for Great Lakes communities, because climate change adaptation recommendations specific to the Great Lakes can be incorporated into the role play. The idea is to first make community members aware of existing policy recommendations, and then have them discuss climate change issues and policies from different perspectives. Participants can learn about the complexity of climate change issues and begin to understand how policies may be made through negotiations.

Image citation:

Maryland Department of Natural Resources,Chesapeake & Coastal Program.



So, how does the role-play exercise work? The exercise is framed as a game, where the goal is to score 100 points—while keeping costs under 25. Each possible policy choice has a cost and a score, which are basically the costs and benefits of each policy. Participants negotiate over which strategies to select, and they must have 8 of 9 committee members approve the final recommendations in order for the proposal to pass. Each participant chooses a character in an advisory board (ranging from a County Commissioner to a member of the Residents Association to a Real Estate Development Association President), and the they make decisions and arguments based on this perspective.

Image citation:

Gwen Shaughnessy. Maryland Department of Natural Resources, Chesapeake & Coastal Program.

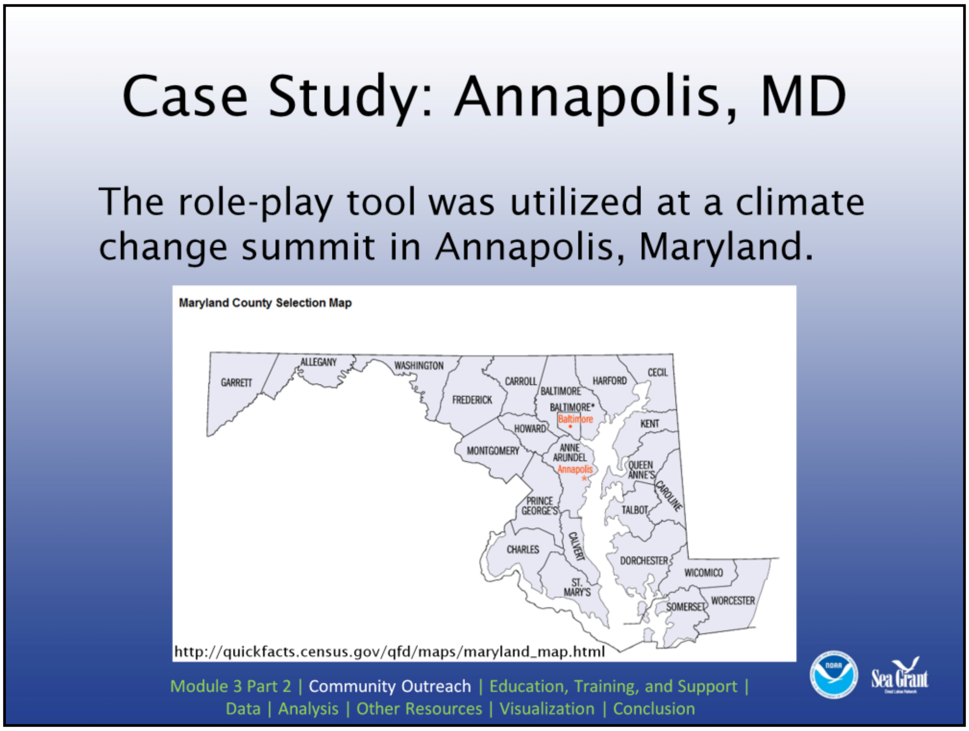
Coast-Smart Communities Adaptation Planning Applications

How can the role-play exercise be incorporated in climate change adaptation planning?

- Community involvement
- Stakeholder participation
- Community discussion

Module 3 Part 2 | Community Outreach | Education, Training, and Support | Data | Analysis | Other Resources | Visualization | Conclusion

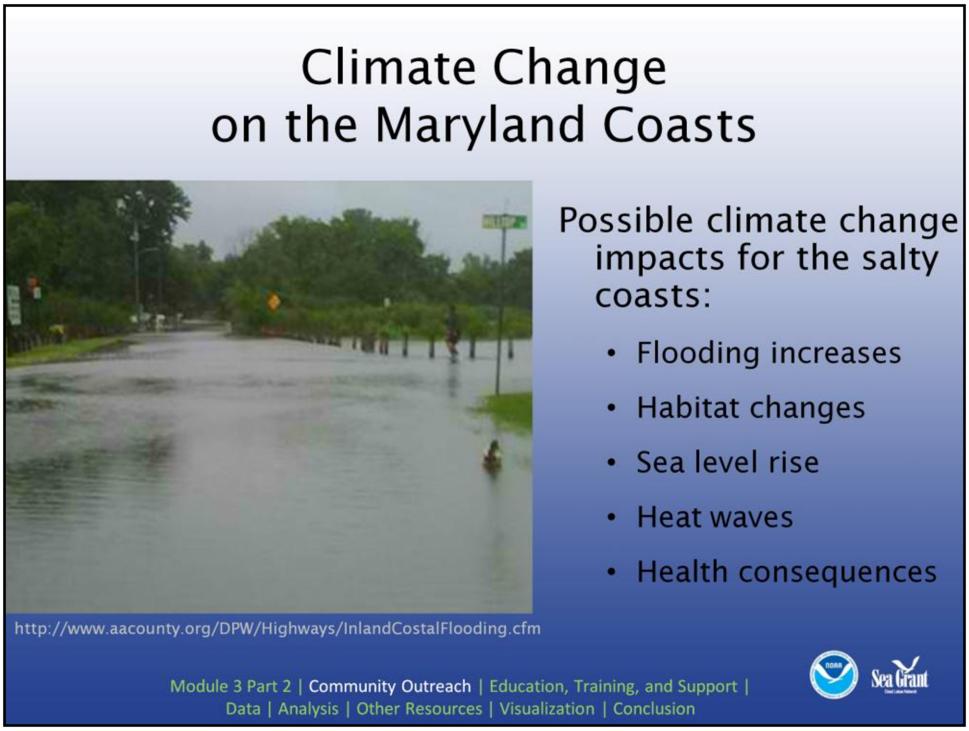
This exercise can be incorporated at various stages of the planning process, but may be best applied at the beginning of the planning process (when the framework is still being established).This exercise can help to encourage participants to become more involved in the climate change adaptation planning and implementation process. For example, involving stakeholders in the exercise will give them an opportunity to voice their opinions and a better understanding of the complexity of the planning process.



In a case study from the Coast Smart website, the role-play exercisewas used at a climate change summit that took place in Annapolis, Maryland.

Source citation:
Maryland Department of Natural Resources, Consensus Building Institute, MIT-USGS. 2009. “Building Coast-Smart Communities: A Role Play Exercise.” http://maryland.coastsmart.org/ (accessed November 15, 2010)

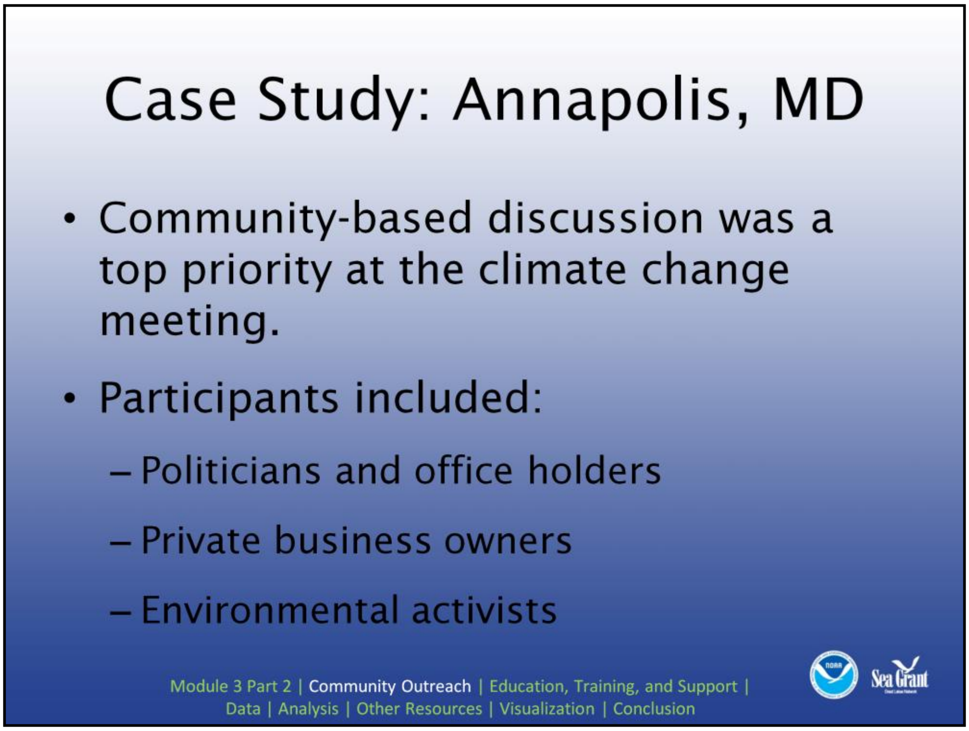
Image citation:
US Census Bureau.“Maryland County Selection Map.” http://quickfacts.census.gov/qfd/maps/maryland_map.html (accessed December 21, 2010)



The climate change issues discussed at the summit were slightly different than the anticipated climate change impacts in the Great Lakes. For the salty coasts, anticipated impacts include flooding increases, habitat changes, sea level rise, heat waves, and human health consequences.

Source citation:
Maryland Commission on Climate Change. 2008."Comprehensive Assessment of Climate Change Impacts in Maryland."*Climate Action Plan*.
http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter2.pdf (accessed December 21, 2010)

Image citation:
Anne Arundel County, MD, Citizens Information Center."Coastal flooding, Bay St (Venice on the Bay)."
http://www.aacounty.org/DPW/Highways/InlandCostalFlooding.cfm (accessed December 21, 2010)



In order to address these anticipated climate change impacts from a number of different viewpoints, a wide variety of participants attended the summit, including "mayors, county commissioners, environmentalists, business leaders, and Maryland state officials." This meeting was held to facilitate community-based discussion on climate change issues facing Maryland coastal communities. Feedback from participants in the role-play exercise was very positive. Participants felt that the interactive role play was a great way to become familiar with different stakeholder perspectives related to climate change adaptation.

Source citation:
Maryland Department of Natural Resources, Consensus Building Institute, MIT-USGS. 2009. "Building Coast-Smart Communities: A Role Play Exercise." http://maryland.coastsmart.org/ (accessed November 15, 2010)

If you are interested in other community outreach tools, please see the Community Outreach section of the handout for more information.

Image citations:

- Environmental Protection Agency.“Green Communities.” http://www.epa.gov/greenkit/basicinformation.htm (accessed December 21, 2010)
- Environmental Protection Agency. 1994. “Environmental Planning for Small Communities: A Guide for Local Decision-Makers.” http://www.epa.gov/nrmrl/pubs/625r94009/625r94009.pdf (accessed December 21, 1010)

The tools in the education, training, and support category help participants find more information on further education and outreach tools, training opportunities, and support tools.

Applications for Climate Change Adaptation Planning for Education, Training, and Support Tools

- Inform public of climate change mechanisms and impacts
- Learn to keep community members involved in adaptation planning
- Learn how to use and find new tools

Module 3 Part 2 | Community Outreach | Education, Training, and Support | Data | Analysis | Other Resources | Visualization | Conclusion

Education, support, and training tools have a variety of applications for climate change adaptation planning. Some tools in this category can be used to inform the public of climate change mechanisms and climate change impacts. Other tools can be used to find additional training or opportunities (such as learning about new tools or finding a tool that fits your needs).

Education, outreach, and training should occur early and often in the adaptation planning process. These tools can be especially helpful for determining strategies for adaptation (Module 2 Part 2) in order to find a tool that fits your targeted climate impact.

An example of such a tool is the NOAA Coastal Services Center website, which directs users to various training sessions.

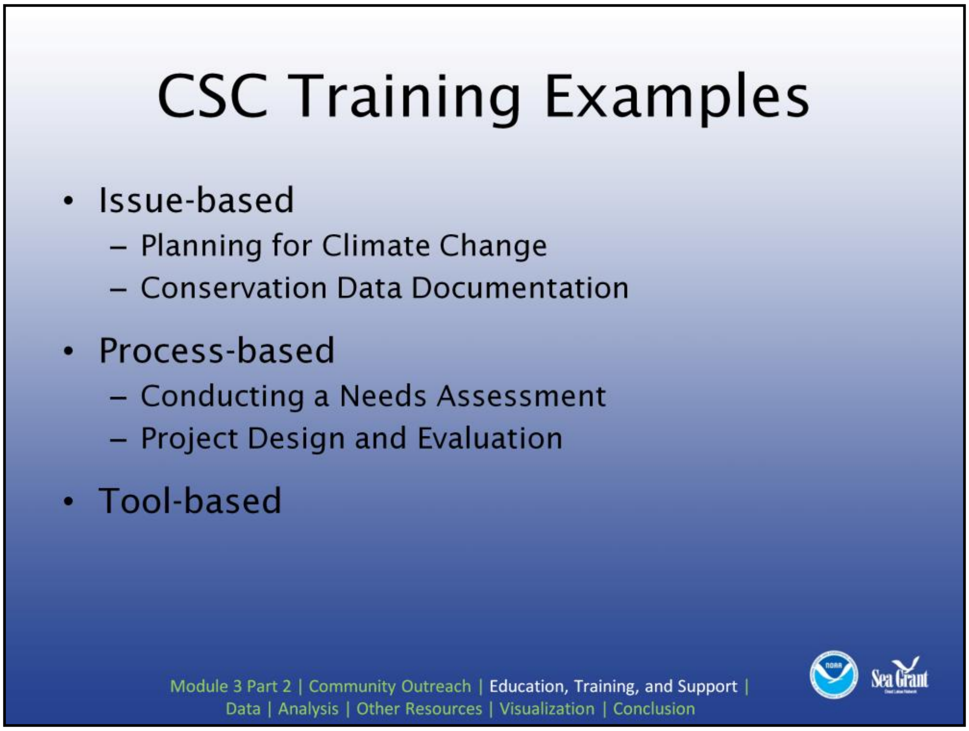
Image citation:

NOAA Coastal Services Center. "Training." http://www.csc.noaa.gov/training/ (accessed December 21, 2010)

NOAA's Coastal Services Center (CSC) Training Factsheet

- **Description:** Training for Coastal Managers (see http://www.csc.noaa.gov/training/)
- **Cost:** Free; May be nominal fee for in-person classes if held at local venue
- **Training/Time Requirements:** Varies
- **Other Requirements/Notes:** Local host required for trainings not held at CSC facility

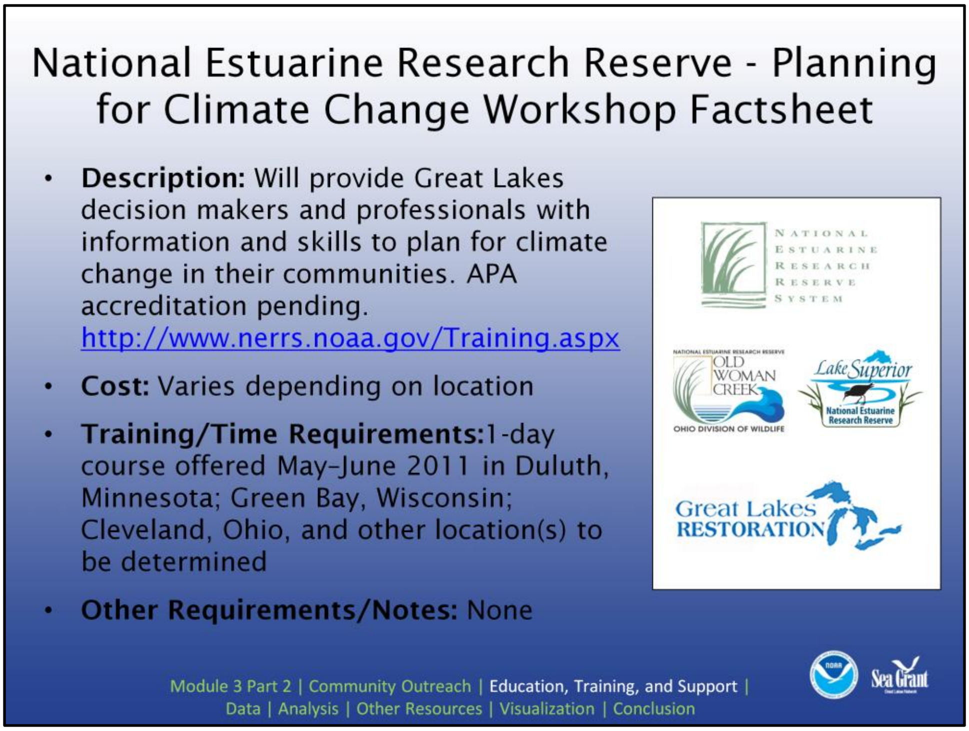
The CSC website directs users to web-based and in-person training resources that address a variety of topics, many of which have applicability to climate change and adaptation planning. The website helps users find a number of online and in-person modules targeted towards coastal managers. The information is free, but a nominal fee may be charged for in-person classes if held at local venue. Time requirements vary depending on the training module. Some in-person classes may be limited to coastal management professionals only, and a local host may be required for trainings not held at CSC facility.



CSC divides training into three main categories: issue-based trainings, process-based trainings, and tool-based trainings. For example, issue-based topics include “Planning for ClimateChange” and “Conservation Data Documentation” and process-based topics include “Conducting a Needs Assessment” and “Project Design and Evaluation.”

Source citation:

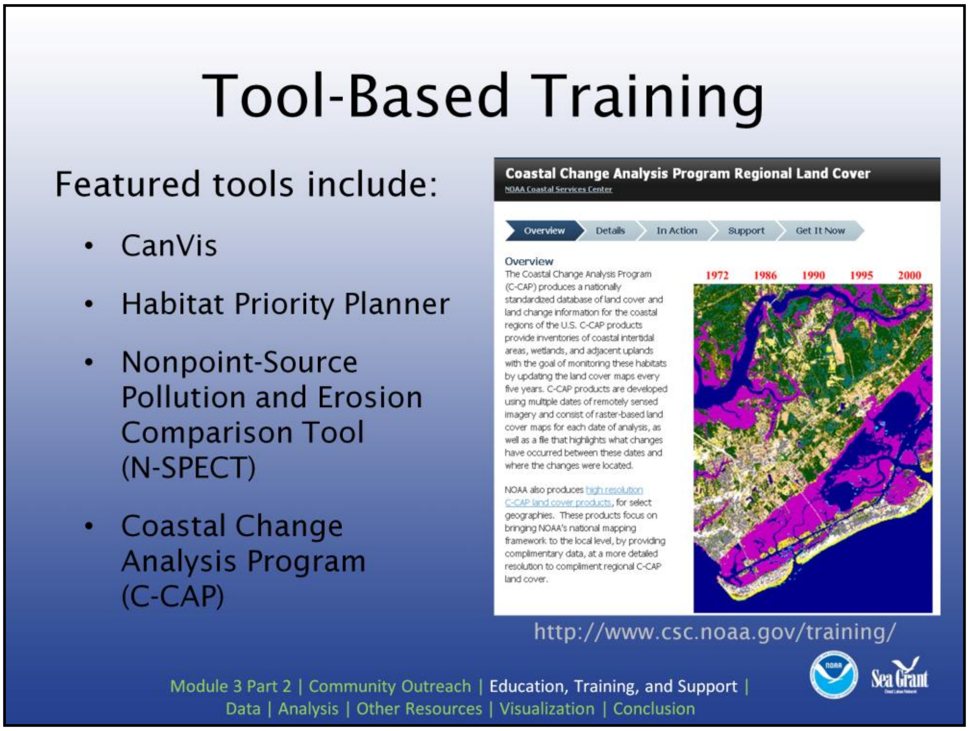
NOAA Coastal Services Center. “Training.” http://www.csc.noaa.gov/training/ (accessed December 21, 2010)



Contacts: Heather Elmer (heather.elmer@dnr.state.oh.us) or Patrick Robinson (patrick.robinson@ces.uwex.edu)

What you will learn:

- Great Lakes regional climate change impacts
- Adaptation planning basics
- Local examples of climate readiness
- Vulnerability assessment
- Adaptation strategies
- Tools and technical resources



The CSC website offers a wide variety of tool-based training that addresses a multitude of climate change impacts. Featured tools include CanVis, Habitat Priority Planner, N-SPECT, and the Coastal Change Analysis Program.

Image citation:

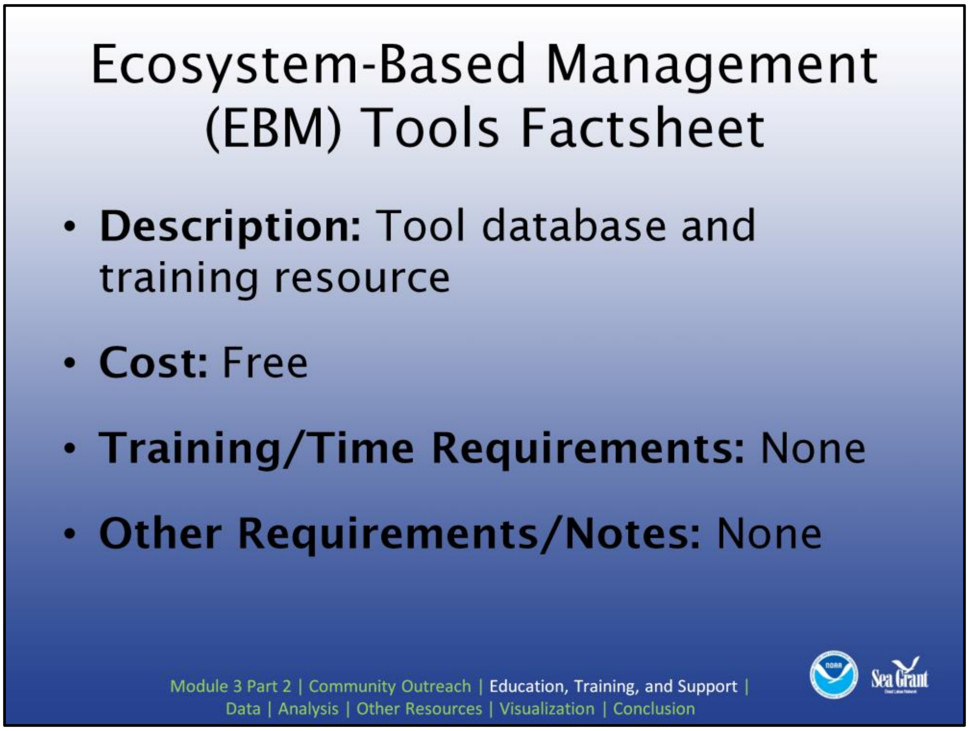
NOAA Coastal Services Center. “Overview - CCAP Regional Land Cover - Digital Coast.”http://www.csc.noaa.gov/digitalcoast/data/ccapregional/ (accessed November 8, 2010)

Training can be useful for climate change adaptation, because decision makers can take advantages of classes that help them learn more about unfamiliar tools, various topics (such as managing coastal areas, zoning, local policies, and climate change), and how to communicate with the public. Depending on the content, the training may not necessarily fit into a particular part of the planning process.

A second tool in this category is the Ecosystem-Based Management Tool Network.

Image citation:

Ecosystem-Based Management Tools Network. “Ecosystem-Based Management Tools Network.” http://www.ebmtools.org/ (accessed December 21, 2010)

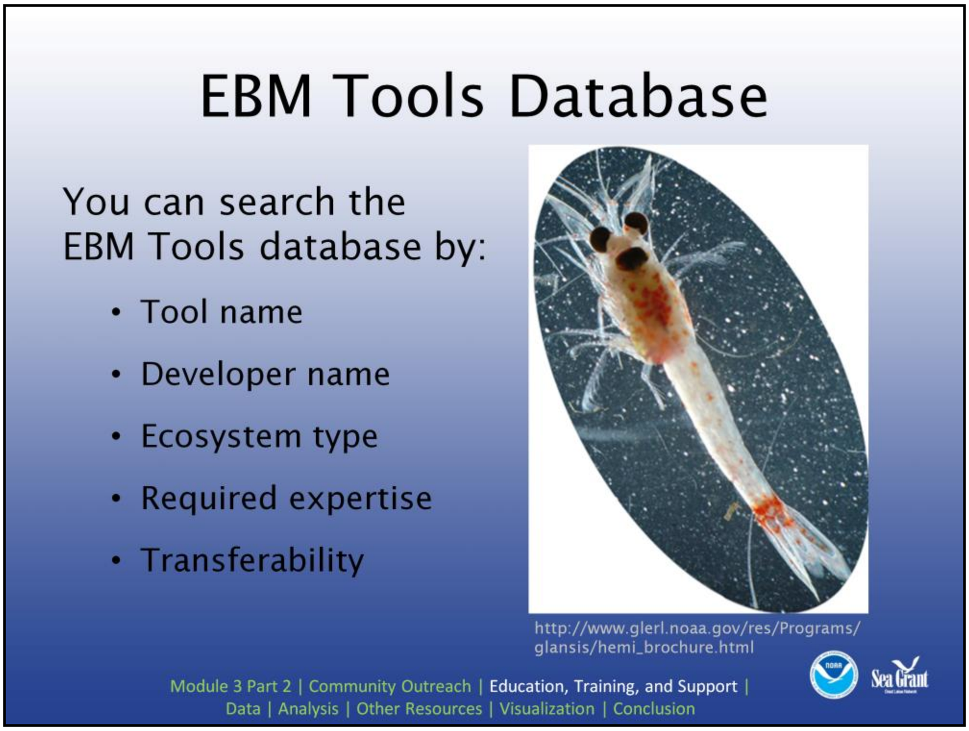


Ecosystem-Based Management (EBM) Tools is a website that links people to a wide variety of tools and toolkits. Users can search the database for a tool that fits specific requirements. The database and website are free to search, and there are no training requirements to learn how to use the website.

EBM Tools offers their own training classes on specific tools, and also directs visitors to tool training opportunities that are offered through other organizations. Additionally, EBM Tools offers monthly demonstrations of tools featured on the website.If you look under the webinars tab on the main website, you can also sign up to receive email alerts of upcoming webinars.

Source citation:

Ecosystem-Based Management Tools Network. “Ecosystem-Based Management Tools Network.” http://www.ebmtools.org/ (accessed December 21, 2010)



The EBM Tools database allows you to search for tools that fit your needs. You can find tools that relate to various climate change impacts (such as ecosystem resiliency and stormwater management). EBM Tools can also help you find a tool that fits your project's limitations (such as available tool expertise) and the geographic location of the project. Additionally, you can search for tools that apply to a specific ecosystem type.

Source citation:
Ecosystem-Based Management Tools Network. "Ecosystem-Based Management Tools Network." http://www.ebmtools.org/ (accessed December 21, 2010)

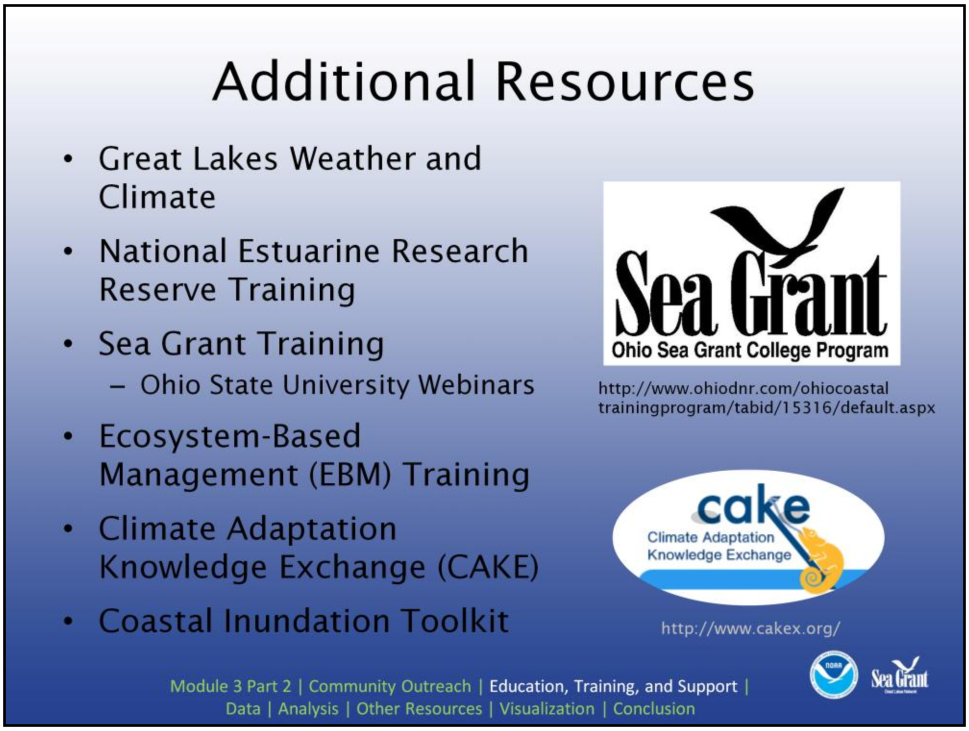
Image citation:
NOAA Great Lakes Aquatic Nonindigenous Information System. "Hemimysis anomala Brochure. Great Lake New Invader: Bloody Red Shrimp (Hemimysis anomala)." http://www.glerl.noaa.gov/res/Programs/glansis/hemi_brochure.html (accessed December 21, 2010)

Climate Change Adaptation Planning Applications

The EBM Tools site:

- Can be very useful for adaptation planning
- Keeps the database up to date with new tools
- Offers many training sessions on a wide variety of tools

Climate change adaptation planning requires a flexible approach, which means that your plan and your tools may need some tweaking from time to time. EBM Tools is an excellent way to find tools that best fit your specific needs—or to find contact information for professionals who may be able to help you. Also, EBM Tools is a great way to learn how to use those new tools effectively, because they offer numerous training sessions. While this website doesn't necessarily fit into a specific step of the planning process, it can be used throughout the process to find the tools and training that you need.

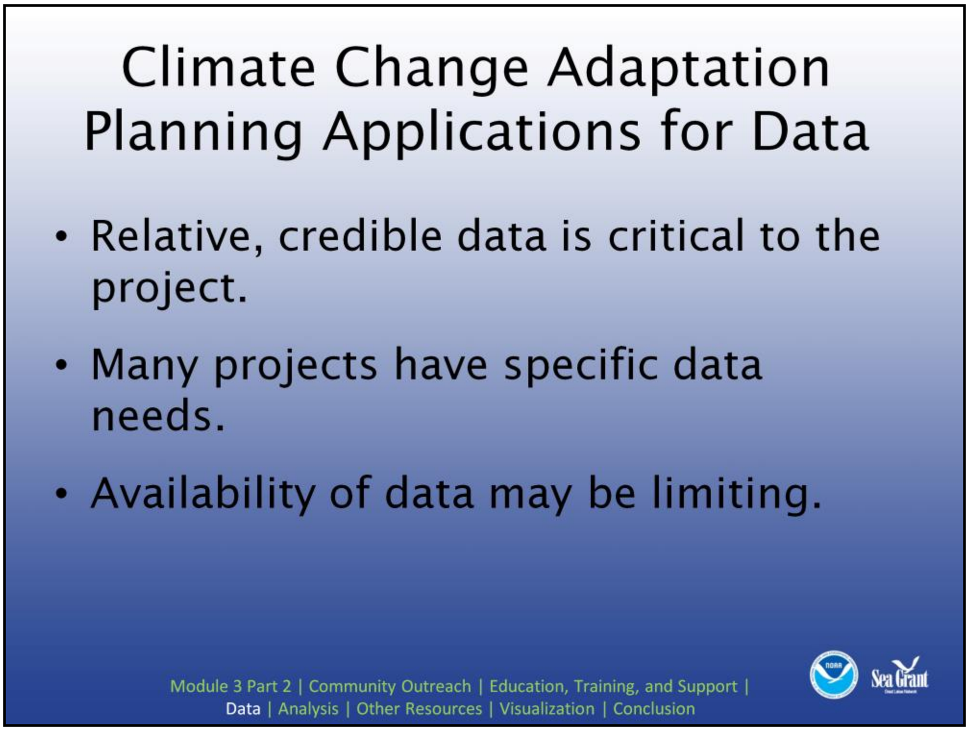


Refer to the handout on additional training tools.

Image citations:

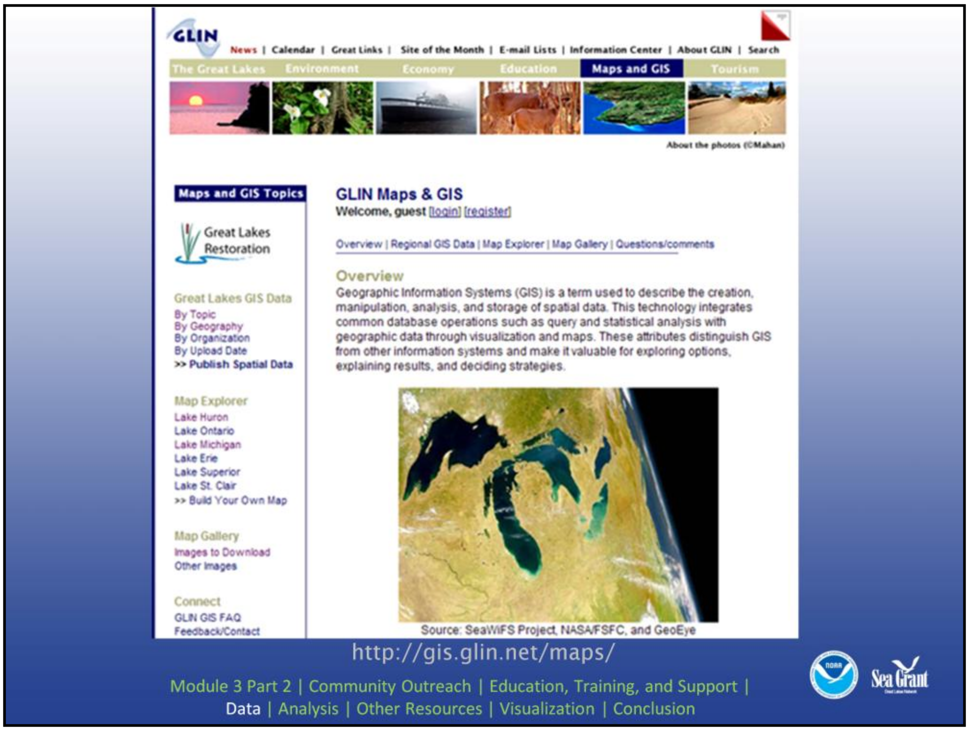
- Ohio.gov. “Ohio Coastal Training Program.” http://www.ohiodnr.com/ohiocoastaltrainingprogram/tabid/15316/default.aspx (accessed December 21, 2010)
- Climate Adaptation Knowledge Exchange. “Climate Adaptation Knowledge Exchange (CAKE).” http://www.cakex.org/ (accessed December 21, 2010)

Data websites help users find data that can be incorporated into other tools or used for analyses.



Finding appropriate data for an adaptation project is crucial. Many adaptation planning tools require additional data that is specific to a city, locality, or region. Land-use data, population, and air quality are examples of the types of data available. The availability of data may limit the user's ability to successfully implement a tool.

(So, this tool likely fits into Part 2: Strategies for Adaptation, because the data from the website can be used for various adaptation strategy tools.)



The Great Lakes Information Network (GLIN) provides maps and GIS data specific to the Great Lakes, and these resources can be downloaded directly from the website.

Image citation:

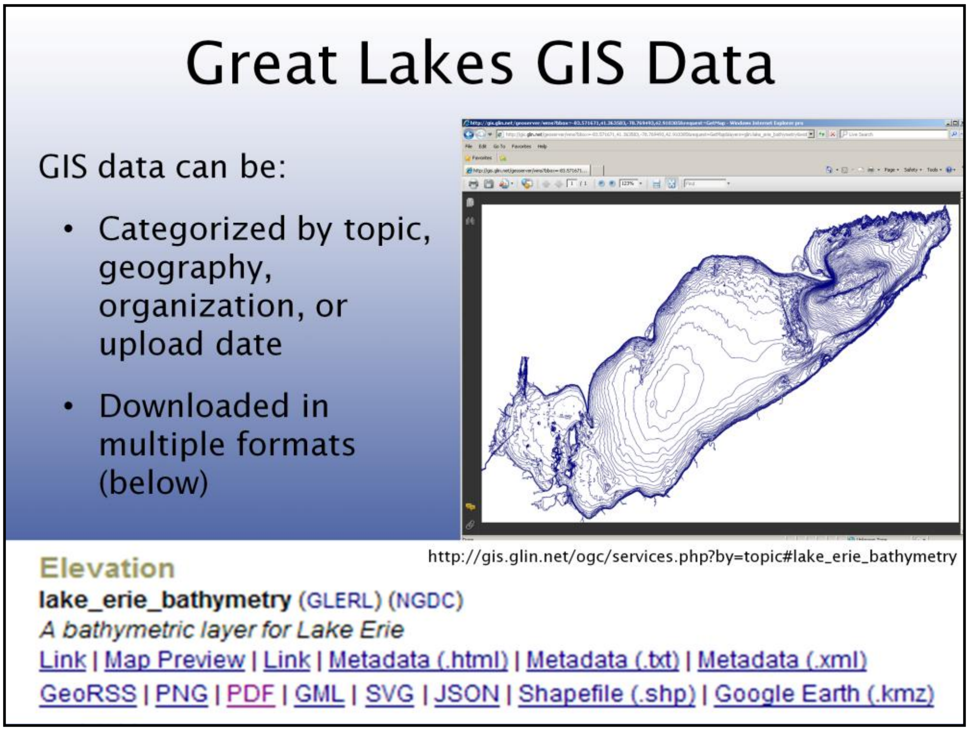
great-lakes.net. "Great Lakes Information Network." http://gis.glin.net/ (accessed November 1, 2010)

The GLIN website offers free, spatial data that is specific to the Great Lakes. GIS skills (or a background in information systems) may be necessary to use some of the data. The GLIN website features include access to:

- Great Lakes GIS data
- Interactive map explorer
- Map gallery that offers downloadable maps of the region
- Other information about the region’s environment, economy, tourism, and education

Source citation:

great-lakes.net.“Great Lakes Information Network.” http://gis.glin.net/ (accessed November 1, 2010)



The GLIN website offers GIS data in multiple formats, including shapefiles, PDFs, and PNGs.On the bottom of the slide, you can see the various data formats and metadata that are available with each data layer. This example shows the files that are associated with the lake_erie_bathymetry layer on the website, and the photo shows what the PDF version of the layer looks like.

Image citation:
great-lakes.net. “Great Lakes Information Network.” http://gis.glin.net/map_explorer.php?lake=erie (accessed November 1, 2010)

Map Explorer offers interactive maps for all of the Great Lakes, as well as Lake St. Clair.You start by choosing a background from various maps and images, and then you add overlays (such as TIGER census datasets and political boundaries) on top of the background map.

Image citation:

great-lakes.net. "Great Lakes Information Network."

The GLIN Map Gallery contains various maps and satellite images of areas in the Great Lakes. The images are free and available for use by the public (as long as proper citation is provided).

great-lakes.net. “Great Lakes Information Network.”

GLIN Adaptation Planning Applications

GLIN provides data that is:

- Trusted
- Reliable
- Specific to the Great Lakes region

Obtaining good data is critical for future analysis and decision making.

Module 3 Part 2 | Community Outreach | Education, Training, and Support |
Data | Analysis | Other Resources | Visualization | Conclusion

GLIN provides reliable, trusted data specific to the Great Lakes, which can be used in GIS and other software tools for climate change adaptation planning. Obtaining good data is important for future analysis and decision making.

GLIN Case Study: Saginaw Bay, MI

Greenways Collaborative

- Developed green infrastructure plan
- Used GIS analysis

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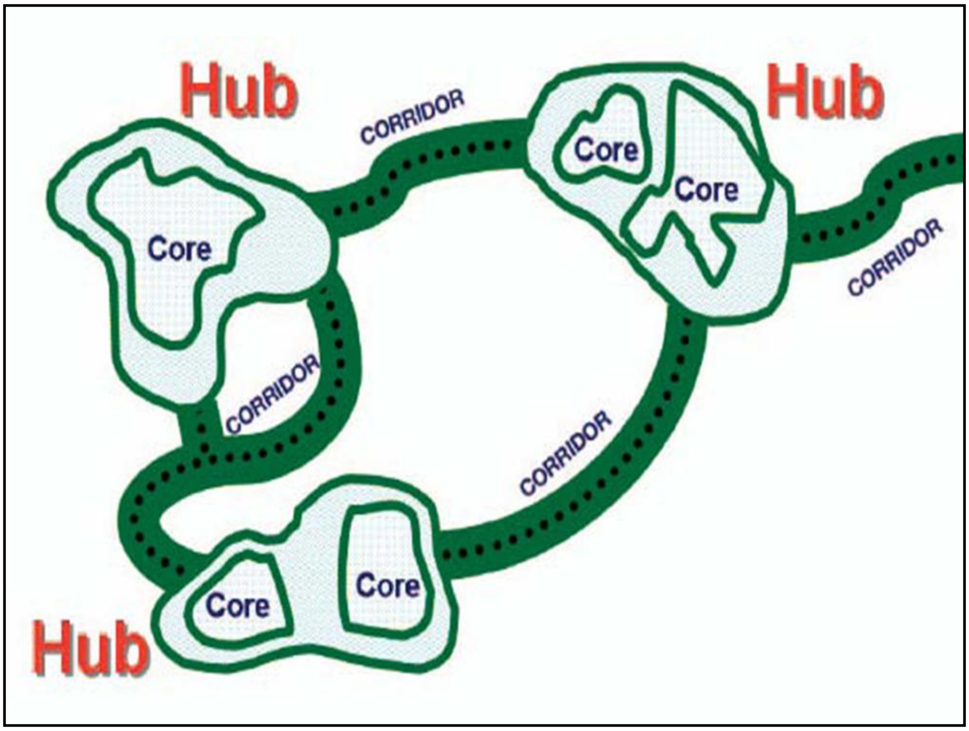
The Saginaw Bay Greenways Collaborative is an example of a case study that used GIS to support a comprehensive green infrastructure plan. This study used GIS to analyze spatial information in order to identify the ecological strengths and weaknesses of an area. GIS suitability models were created to identify the most important parcels based on a set of criteria. For example, one criteria for a parcel might be that 250 acres of interior natural cover were required.

Source citation:

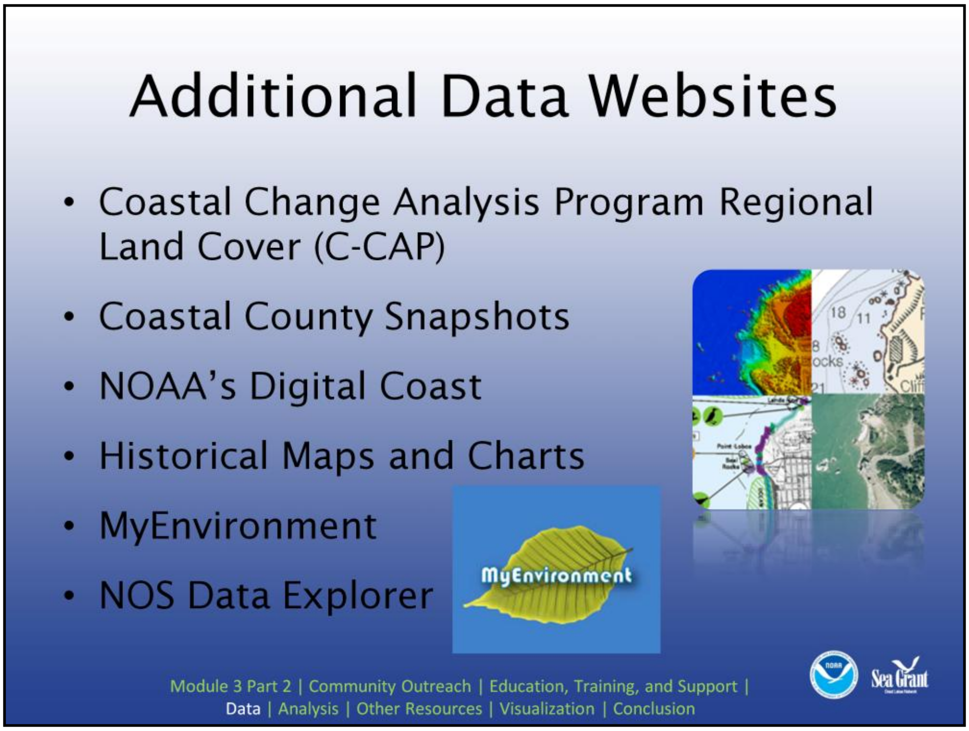
The Conservation Fund. 2005. “Saginaw Bay Greenways Collaborative, Michigan.”



Hubs were specified as natural areas containing at least one core area greater than 300 feet across. The collaborative then used GIS to create the least-cost path analysis to identify corridors between hubs. The preliminary plan was created as a GIS map that could be shared with stakeholders and the public for comment and revisions.

Source and image citation:

The Conservation Fund. 2005. "Saginaw Bay Greenways Collaborative, Michigan."

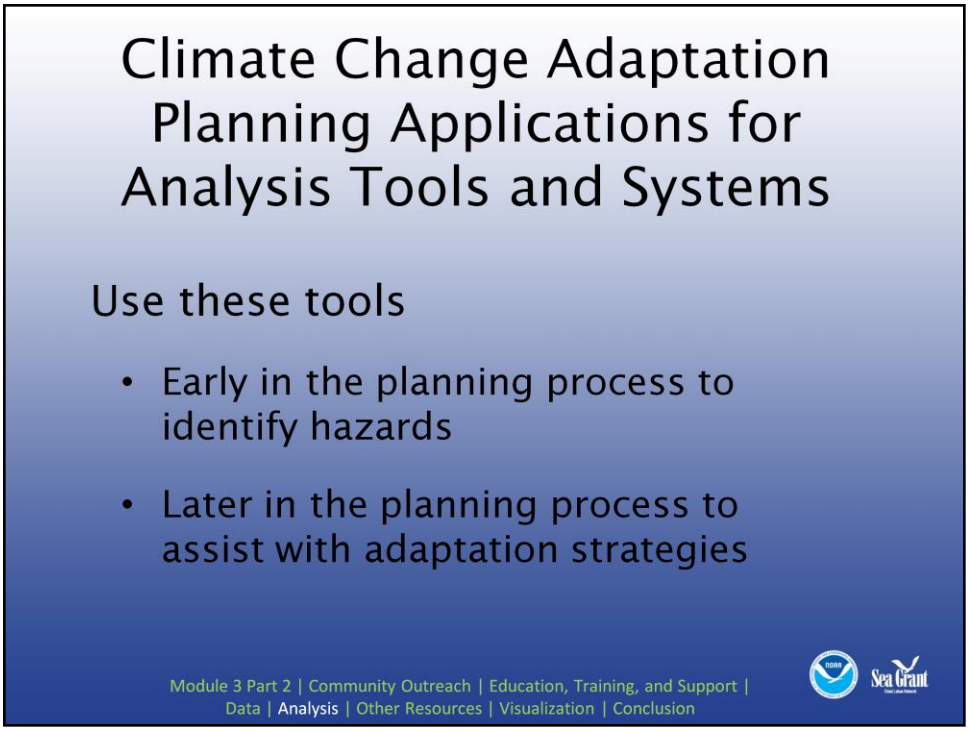


Some other data websites that provide information specific to the Great Lakes include NOAA's Digital Coast, Historical Maps and Charts, MyEnvironment, and the NOS Data Explorer. More information is available in the handout.

Image citations:

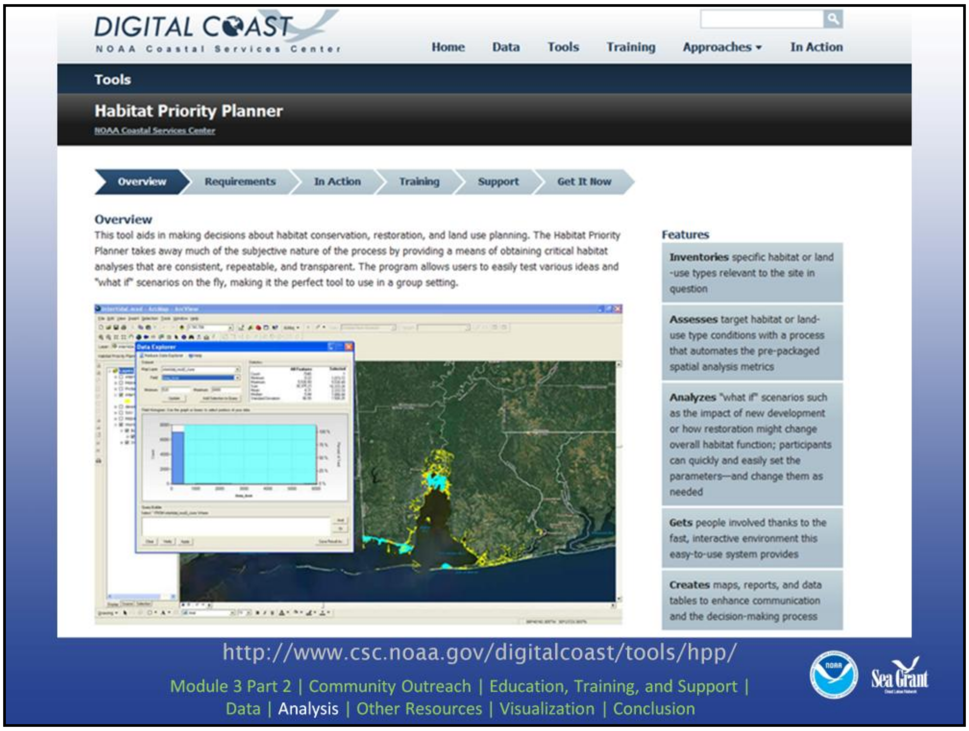
- National Ocean Service. "NOS Data Explorer." http://oceanservice.noaa.gov/dataexplorer/ (accessed December 28, 2010)
- Environmental Protection Agency. "My Environment." http://www.epa.gov/myenvironment/ (accessed December 28, 2010)

Analysis tools and systems help determine possible effects of decisions, changes, or hazardous events on communities and/or environmental systems.



Analysis tools and systems encompass of a wide range of tools, which means that tools in this category can be used at different parts of the adaptation planning process.

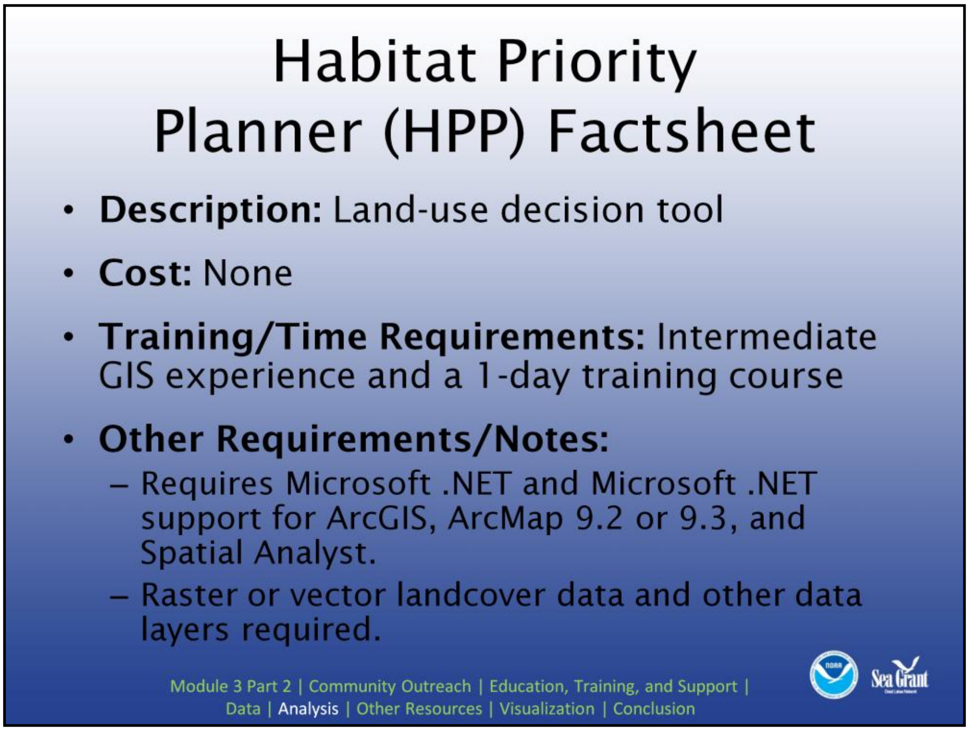
- Some of the tools may be used earlier in the process to identify hazards and assess vulnerabilities and opportunities (as described in Part 1 of Module 2).
- Many of the tools can be used later in the process, when decision makers are looking for tools to assist them with adaptation strategies (as described in Part 2 of Module 2).



One analysis system tool that can be used in the climate change adaptation planning process is the Habitat Priority Planner, which can be downloaded from the NOAA Digital Coast website.

Image citation:

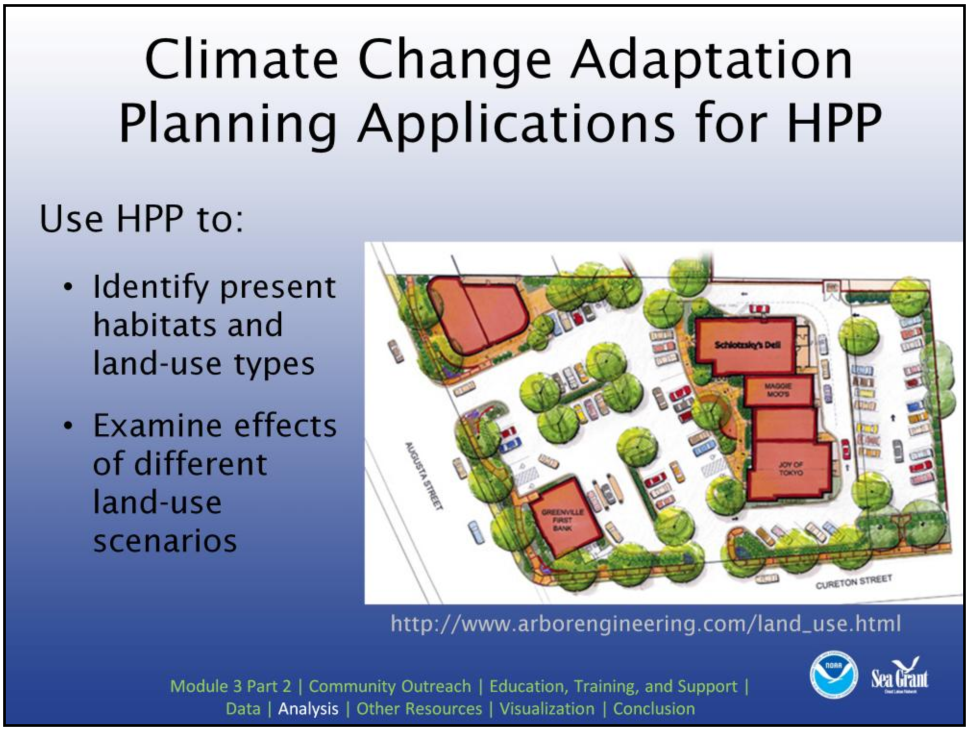
NOAA Coastal Services Center Digital Coast."Habitat Priority Planner." http://www.csc.noaa.gov/digitalcoast/tools/hpp/ (accessed December 21, 2010)



Habitat Priority Planner (HPP) is a NOAA Coastal Services Center tool that can be downloaded free of charge from the Coastal Services Center website. This tool offers decision makers a way to incorporate habitat restoration into decisions about how to best use land. HPP does require that users are experienced with using ArcGIS (so that they can find correct data and use the software) and they must have ArcGIS 9.2 or higher installed on their computer.

NOAA Coastal Services Center offers a 1-day training session to help users acquire the knowledge they need to use the tool successfully.A small fee is charged for participation; contact NOAA Coastal Services Center for more information.

Source citation:
NOAA Coastal Services Center Digital Coast."Habitat Priority Planner." http://www.csc.noaa.gov/digitalcoast/tools/hpp/ (accessed December 21, 2010)

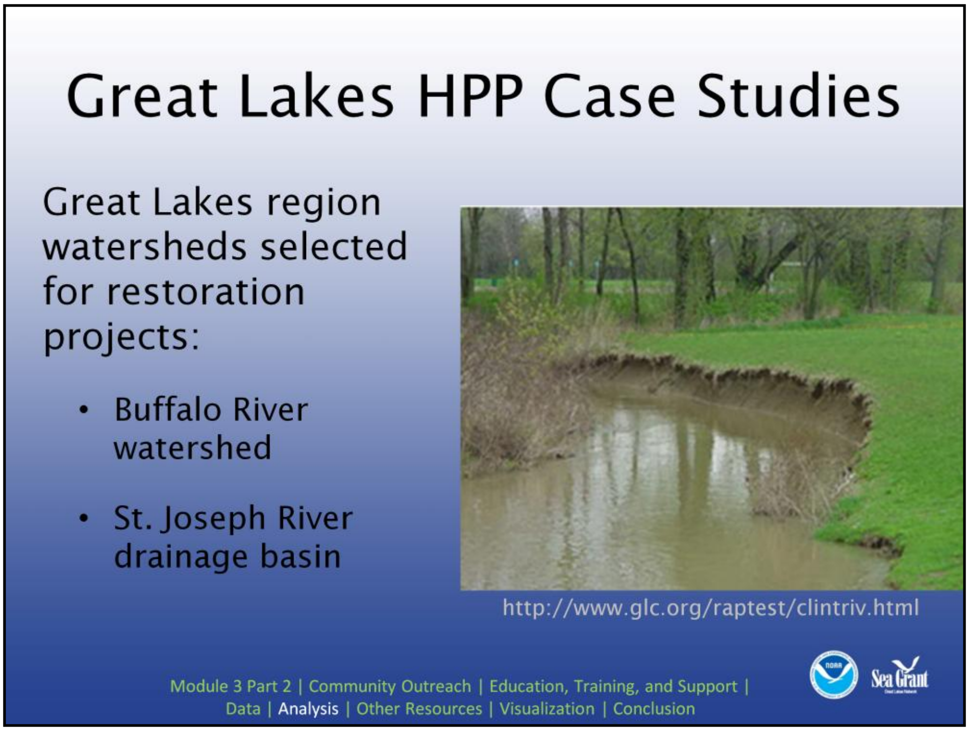


HPP can be used to identify areas that are best-suited for a specific purpose:

- You can use this software to examine what may happen to local habitats under various development scenarios.
- Additionally, if you give HPP certain conditions and requirements, it can help you find areas that fit those requirements (e.g., chose best areas for potential restoration projects).

The software also includes various output formats (such as maps, tables, and reports) to help display and interpret results.

Image citation:
Arbor Engineering. "Land Use Planning."
http://www.arborengineering.com/land_use.html (accessed December 21, 2010)



In a case study from the HPP website, two sections of watersheds in the Great Lakes region were chosen for habitat restoration projects as part of the Great Lakes Regional Collaboration Project. The Buffalo River watershed section is located in New York, while the section of St. Joseph River drainage basin is located in Indiana.

In both projects, HPP was used to perform a crucial analysis of areas that were suitable for habitat restoration. Specific qualifications were entered into the system and areas that fit those requirements were selected.

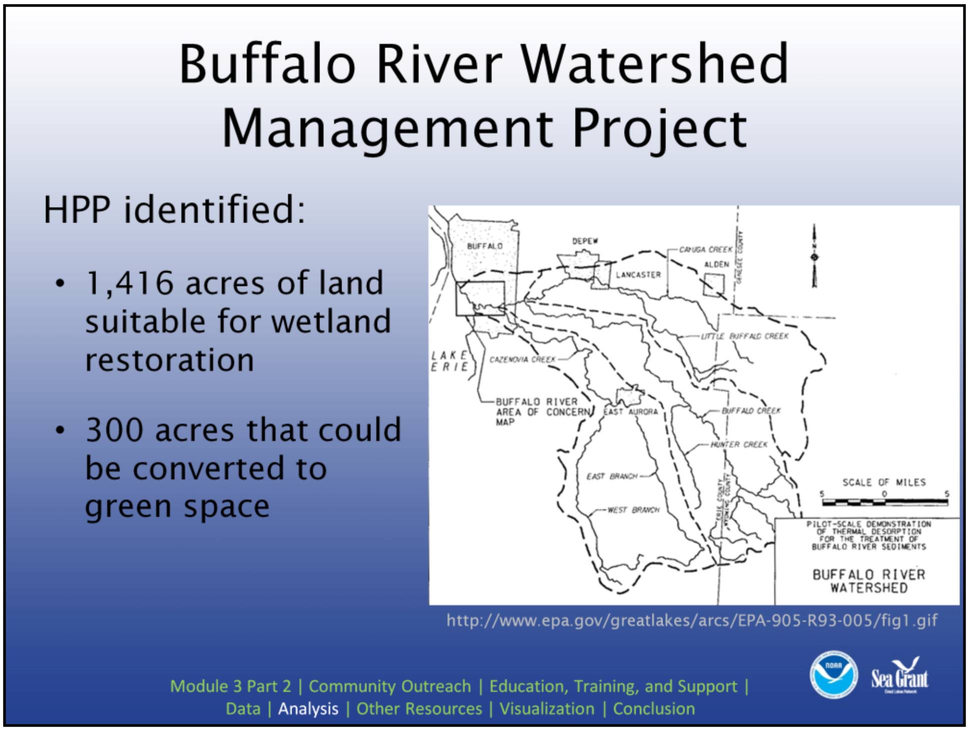
Source citation:
NOAA Coastal Services Center Digital Coast. “Advancing Restoration in the Great Lakes Region.” http://www.csc.noaa.gov/digitalcoast/action/advancerestoration.html (accessed December 21, 2010)

Image citation:
Environmental Protection Agency.“Della Park Bio-Engineered Project, an example of habitat restoration in the Clinton River AOC.” http://www.glc.org/raptest/clintriv.html (accessed December 21, 2010)

Based on some background on the Buffalo River watershed, the portion of the Buffalo River that was used in this project was located in New York state. This water system has many environmental concerns related to the quality of the water, pollution, and habitat degradation—all of which are likely to be exacerbated by climate change.

Source citation:
Buffalo/Niagara River Keeper.“Issues Affecting the AOC.” http://bnriverkeeper.org/programs/buffalo-river-remedial-action-plan/issues-affecting-the-aoc/ (accessed December 21, 2010)

Image citation:
Buffalo/Niagara River Keeper. “Contaminated Sediments.”http://bnriverkeeper.org/programs/buffalo-river-remedial-action-plan/issues-affecting-the-aoc/ (accessed December 21, 2010)



Given the contamination, water quality, and habitat degradation issues facing the Buffalo River watershed, the goals of the project were focused on wetland restoration and pollution reduction from non-point sources. The HPP software was used to identify areas that weresuitable for conversion to (1) wetlands and (2) green space. The software was able to identify 1,416 acres that met the conditions for suitable for wetland restoration, and 300 acres that met the conditions for suitable for conversion to green space.

Source citation:
NOAA Coastal Services Center Digital Coast. “Advancing Restoration in the Great Lakes Region.” http://www.csc.noaa.gov/digitalcoast/action/advancerestoration.html (accessed December 21, 2010)

Image citation:
Environmental Protection Agency.“Buffalo River Watershed.” http://www.epa.gov/greatlakes/arcs/EPA-905-R93-005/fig1.gif (accessed December 21, 2010)

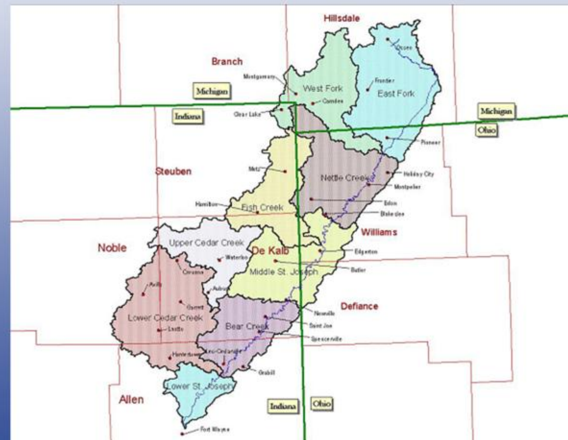
The other restoration project in this case study took place in the St. Joseph watershed, which is located in Indiana. This watershed faces many issues that arise from the high concentration of agricultural activities in the area. For this study, the particular issues of concern were high concentrations of herbicides and other agriculture runoff in the hydrology system.

Source citation:
NOAA Coastal Services Center Digital Coast. “Advancing Restoration in the Great Lakes Region.” http://www.csc.noaa.gov/digitalcoast/action/advancerestoration.html (accessed December 21, 2010)

Image citation:
NOAA Ocean Service Education.“Return Nonpoint Source Pollution: Agricultural Operations.” http://oceanservice.noaa.gov/education/kits/pollution/media/supp_pol06a.html (accessed December 21, 2010)

St. Joseph River Habitat Restoration Project

HPP identified 2,419 acres (out of 23,000) to target for wetland restoration



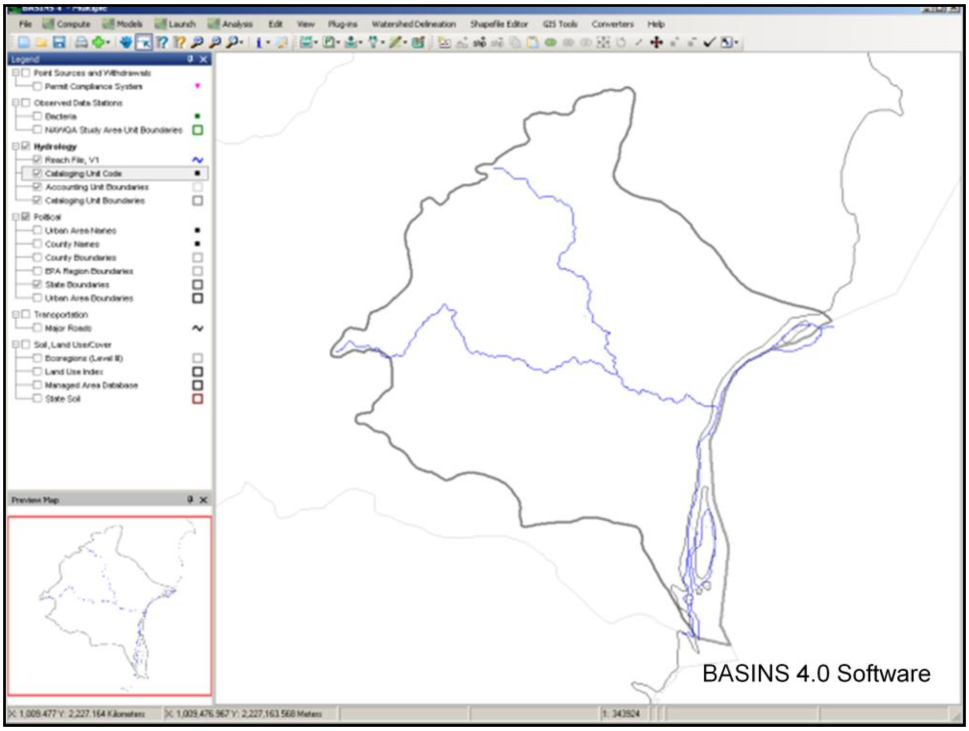
http://www.sjrwi.org/sites/default/files/images/1.gif

Module 3 Part 2 | Community Outreach | Education, Training, and Support | Data | Analysis | Other Resources | Visualization | Conclusion

The main focus of this project was to identify areas that could be returned to wetlands in order to help buffer against agricultural runoff.Out of 23,000 acres considered, the HPP software identified around 2,500 acres that fit the wetland conversion requirements.

Source citation:
NOAA Coastal Services Center Digital Coast. "Advancing Restoration in the Great Lakes Region."
http://www.csc.noaa.gov/digitalcoast/action/advancerestoration.html (accessed December 21, 2010)

Image Citation:
St. Joseph River Watershed Initiative."St. Joseph River Watershed."
http://www.sjrwi.org/sites/default/files/images/1.gif (accessed December 21, 2010)



This is a picture of a watershed in Detroit, Michigan, in the BASINS 4.0 software. BASINS is the second analysis system that we would like to showcase, because of its applicability to adaptation planning.

Image citation:
Environmental Protection Agency. *Better Assessment Science Integrating Point & Non-point Sources (BASINS)*. Computer software, version 4.0 (April 12, 2007).
http://water.epa.gov/scitech/datait/models/basins/b3webdwn.cfm (accessed December 21, 2010)

BASINS 4.0 Factsheet

- **Description:** Maps effects of climate change on watersheds
- **Cost:** Free
- **Training/Time:** 4.5-hour training session
- **Other requirements/Notes:**
  - Background experience (watershed hydrology and water quality)
  - ArcGIS experience recommended

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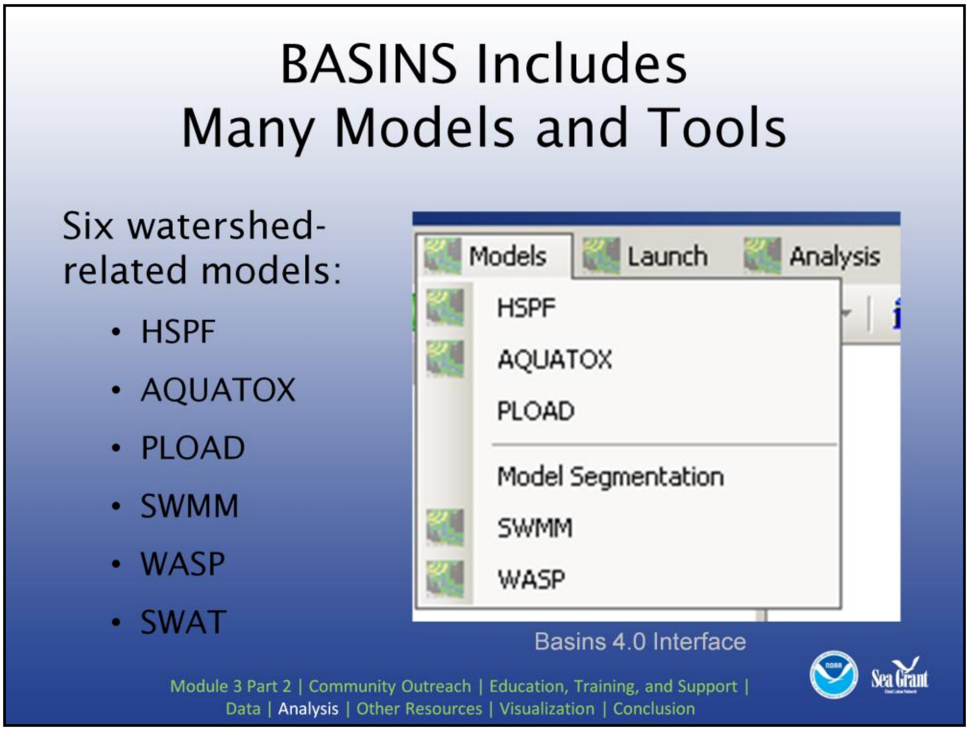
The Environmental Protection Agency's BASINS 4.0 allows users to explore possible effects of climate change on watersheds and water quality. The software can be downloaded for free and there is a 4.5-hour training session offered through the EPA. (There are also PowerPoint lectures and exercises available on EPA website.) Having experience with ArcGIS will make using this tool easier, but you do not need ArcGIS software on your computer. (BASINS is an open-source GIS tool that can be run independently of ArcGIS).



BASINS has six watershed-related models available in the software. Each model runs by itself, but is also interlinked with the other models.

1. HSPF is a watershed model.
2. AQUATOX is a model that simulates interactions between pollutants and biotic life within an aquatic system.
3. PLOAD is used to determine the amount of pollutants a watershed is carrying.
4. SWMM is the Storm Water Management Model, which shows how precipitation and various pollutants can move through and effect stormwater systems.
5. WASP is a Water Quality Analysis Simulation program, which can be used to model water quality in watersheds.
6. The SWAT model simulates (a) the cycling of nutrients and (b) how cycling substances (such as pesticides, nutrients, erosion and sediment materials, and bacteria) move through hydrologic systems.

Source citations:

- **HSPF:** Environmental Protection Agency. 2009. *BASINS 4.0 Climate Assessment Tool (CAT): Supporting Documentation and User's Manual (Final Report).* U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/088F.

- **AQUATOX:**Environmental Protection Agency. "AQUATOX—Linking water quality and aquatic life." http://water.epa.gov/scitech/datait/models/aquatox/index.cfm (accessed December 22, 2010)

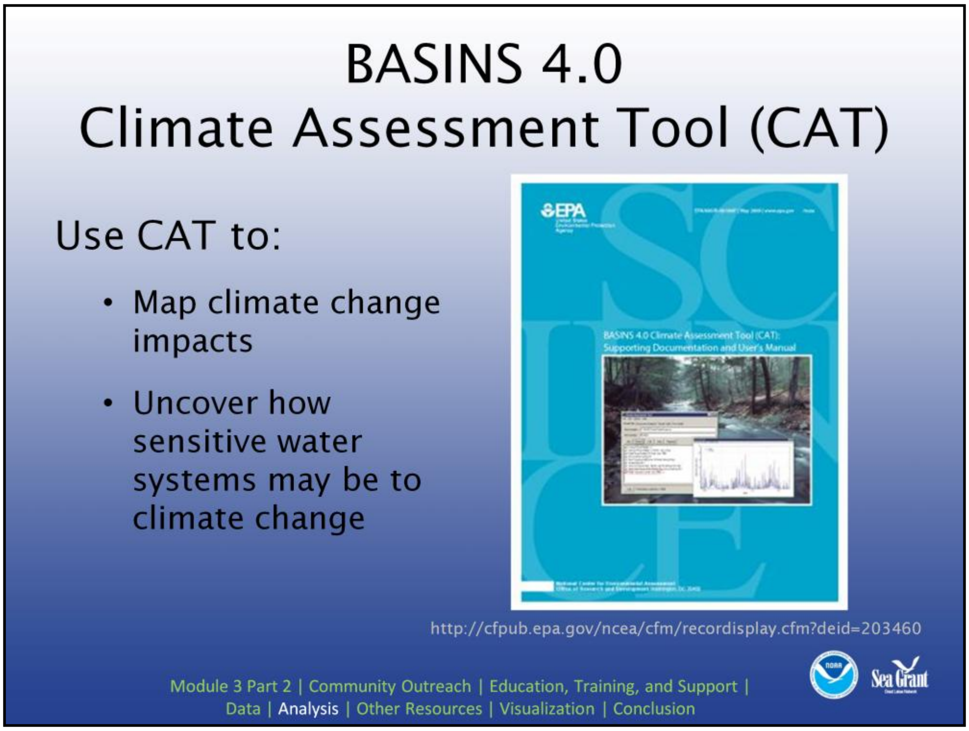
- **PLOAD:** Environmental Protection Agency. 2001. *PLOAD version 3.0 An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects.*http://water.epa.gov/scitech/datait/models/basins/upload/2002_05_10_BASINS_b3docs_PLOAD_v3.pdf

- **SWMM:** Environmental Protection Agency. 1995. *SWMM Windows Interface User's Manual.*http://water.epa.gov/scitech/datait/models/upload/1999_11_03_models_swmmmanual.pdf (accessed December 22, 2010)

- **SWAT:** Environmental Protection Agency. 2001. *Better Assessment Science Integrating point and Nonpoint Sources Version 3.0 User's Manual.* http://water.epa.gov/scitech/datait/models/basins/upload/2009_04_03_BASINS_b3docs_usermanual.pdf (accessed December 23, 2010)

Image citation:

Environmental Protection Agency. *Better Assessment Science Integrating Point & Non-point Sources (BASINS).* Computer software, version 4.0 (April 12, 2007). http://water.epa.gov/scitech/datait/models/basins/b3webdwn.cfm (accessed December 21, 2010)



One feature of the BASINS 4.0 analysis system that could be very useful for climate change adaptation planning is the Climate Assessment Tool (CAT). This tool allows users to examine possible effects of climate change on watersheds, including the water quality in the watersheds. The CAT model is linked with the HSPF watershed model, so that pollutants in watersheds can be modeled.

Source citation:

Environmental Protection Agency. May 2009. *BASINS 4.0 Climate Assessment Tool (CAT): Supporting Documentation and User's Manual*.http://water.epa.gov/scitech/datait/models/basins/upload/BASINS-CAT_USER_MANUAL_FINAL.PDF (accessed December 21, 2010)

Image citation:

Environmental Protection Agency. *BASINS 4.0 Climate Assessment Tool (CAT): Supporting Documentation and User's Manual (Final Report).* http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=203460 (accessed December 23, 2010)

BASINS 4.0 Applications

BASINS is applicable to the following categories:

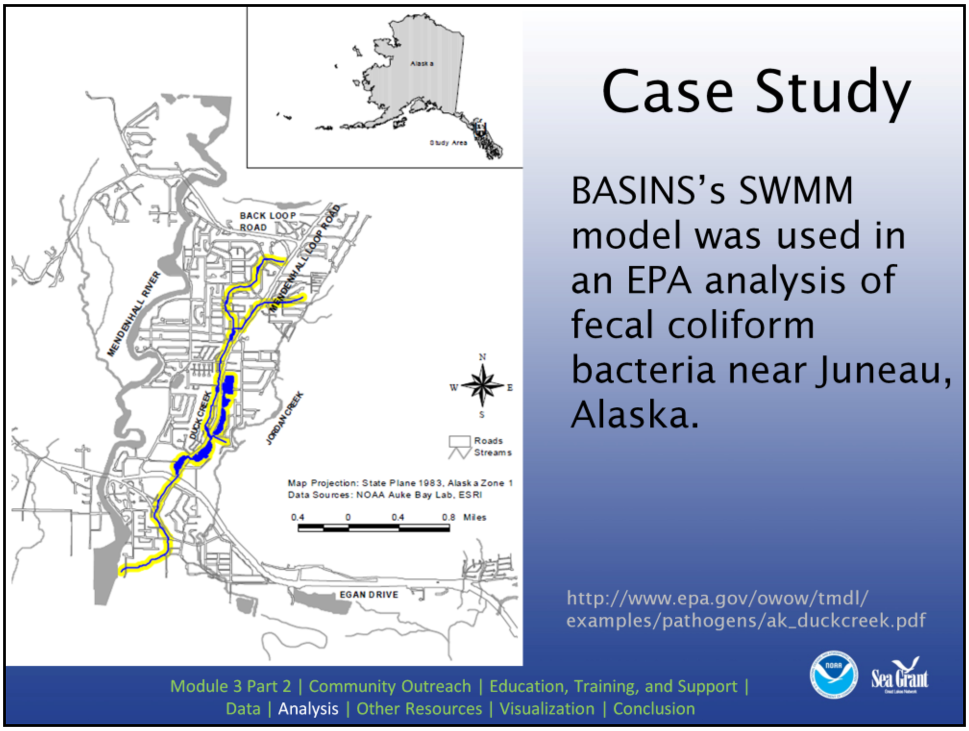
- Stormwater management
- Flood hazard reduction
- Drought
- Air and water quality
- Ecosystem resilience

BASINS
Better Assessment Science Integrating Point and Nonpoint Sources

http://www.eng.auburn.edu/users/doughmp/LULC_tutorials/LULC-outline.htm

BASINS is most likely to fit into the planning process later on, when decision makers are looking for strategies for adaptation. (Part II: Strategies for adaptation)It fits a wide range of impact areas including: Stormwater Management, Flood Hazard Reduction, Drought, Air and Water Quality, and Ecosystem Resilience. Since climate change is likely to cause increased events of extreme precipitation, and other effects on hydrologic systems, this tool can be a valuable resource for climate change adaptation planning.

Image Citation:
“Land Use/Land Cover and other data (EPA’s BASINS 3.0).” Auburn University. Web. 23 Dec. 2010.<http://www.eng.auburn.edu/users/doughmp/LULC_tutorials/LULC-outline.htm>.



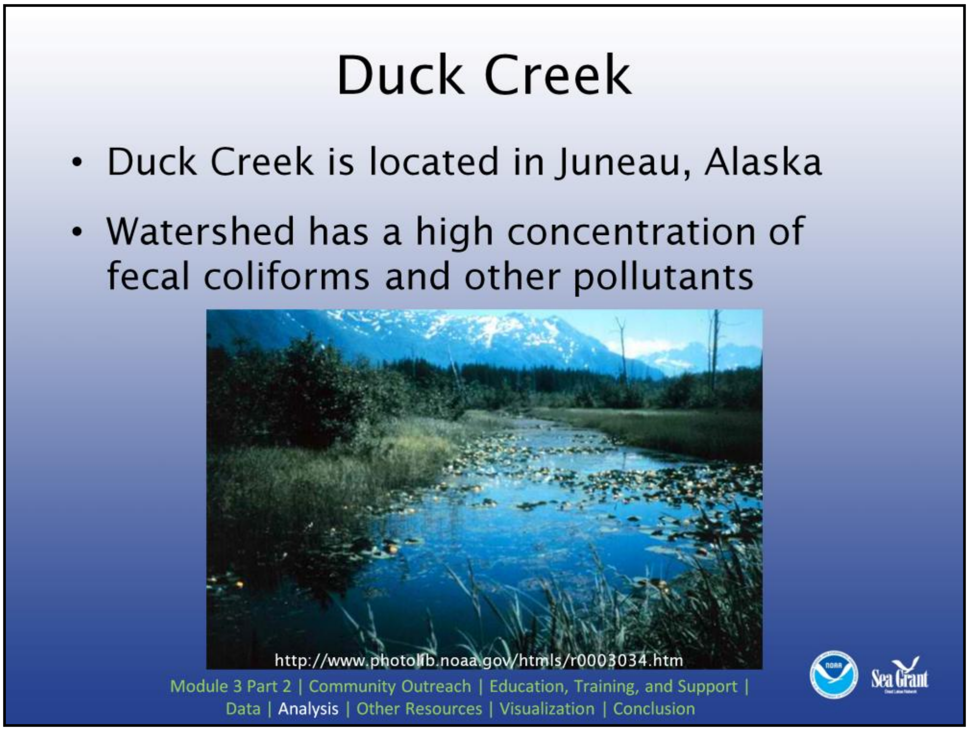
The SWMM model from BASINS 4.0 was used by theEPA in an analysis of fecal coliform bacteria in the Duck Creek watershed near Juneau, Alaska. This case study is just one example of the many climate change adaptation planning applications of the BASINS 4.0 analysis system.

Source citation:

Environmental Protection Agency. 2000. *Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in the Waters of Duck Creek in Mendenhall Valley, Alaska.* http://www.epa.gov/owow/tmdl/examples/pathogens/ak_duckcreek.pdf (accessed December 23, 2010)

Image citation:

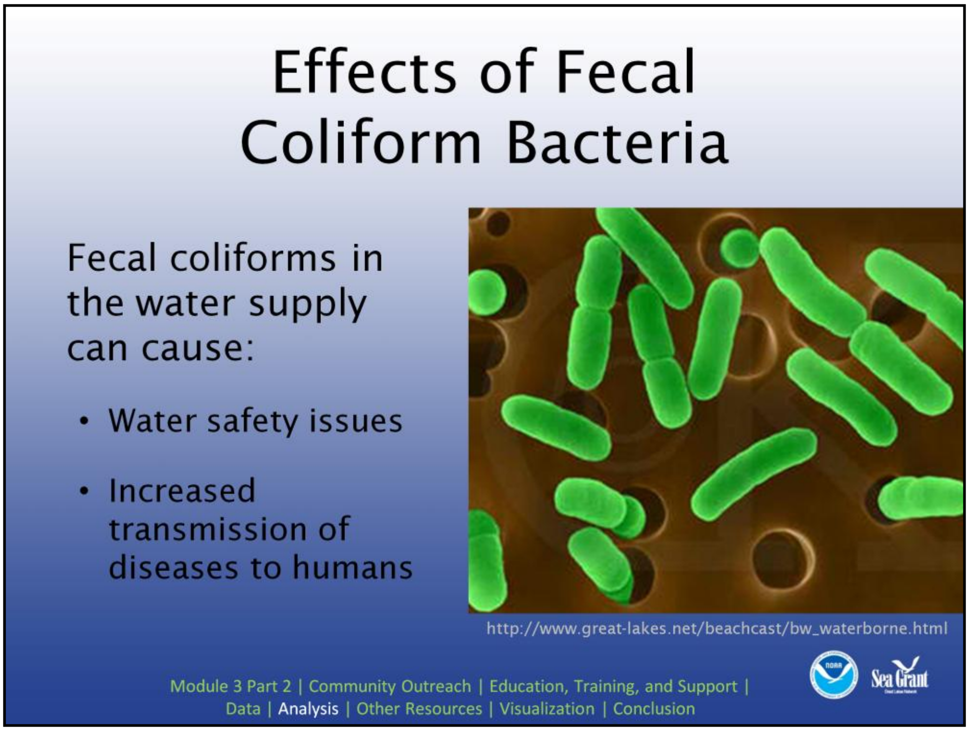
Environmental Protection Agency. 2000. *Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in the Waters of Duck Creek in Mendenhall Valley, Alaska.* http://www.epa.gov/owow/tmdl/examples/pathogens/ak_duckcreek.pdf (accessed December 23, 2010)



The Duck Creek Watershed is located in Juneau, Alaska, and has a high percentage of urban lands. Due to the high concentration of fecal coliforms and other pollutants in its waters, Duck Creek was put on the EPA's 1998 303(d) list of impaired waters in Alaska. Most of this bacteria can be traced to wastes from the urban areas and animals (mostly pets but also some wildlife). Often, stormwater and sewage system overflows lead to this type of problem. Climate change is likely to aggravate this issue, because increased events of extreme precipitation are expected for the Great Lakes region—which would in turn cause more incidences of combined stormwater and sewage system overflows.

Source citation:
Environmental Protection Agency. 2000. *Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in the Waters of Duck Creek in Mendenhall Valley, Alaska.*
http://www.epa.gov/owow/tmdl/examples/pathogens/ak_duckcreek.pdf (accessed December 23, 2010)

Image citation:
NOAA Photo Library: NOAA Auk Bay Lab, K. Koski, 1999. “A Pond on Duck Creek.” http://www.photolib.noaa.gov/htmls/r0003034.htm (accessed December 23, 2010)



High concentrations of fecal coliforms cause water safety issues and consequences to human health. The bacteria can cause increased incidence "gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases".

Source citation:
Environmental Protection Agency. 2000. *Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in the Waters of Duck Creek in Mendenhall Valley, Alaska.* http://www.epa.gov/owow/tmdl/examples/pathogens/ak_duckcreek.pdf (accessed December 23, 2010)

Image citation:
Great Lakes Beach Coast, Great Lakes Information Network. "E. Coli and Other Waterborne Pathogens." http://www.great-lakes.net/beachcast/bw_waterborne.html (accessed December 23, 2010)

Role of SWMM

- Selected to model urban runoff
- Used to establish a Total Maximum Daily Load (TMDL)

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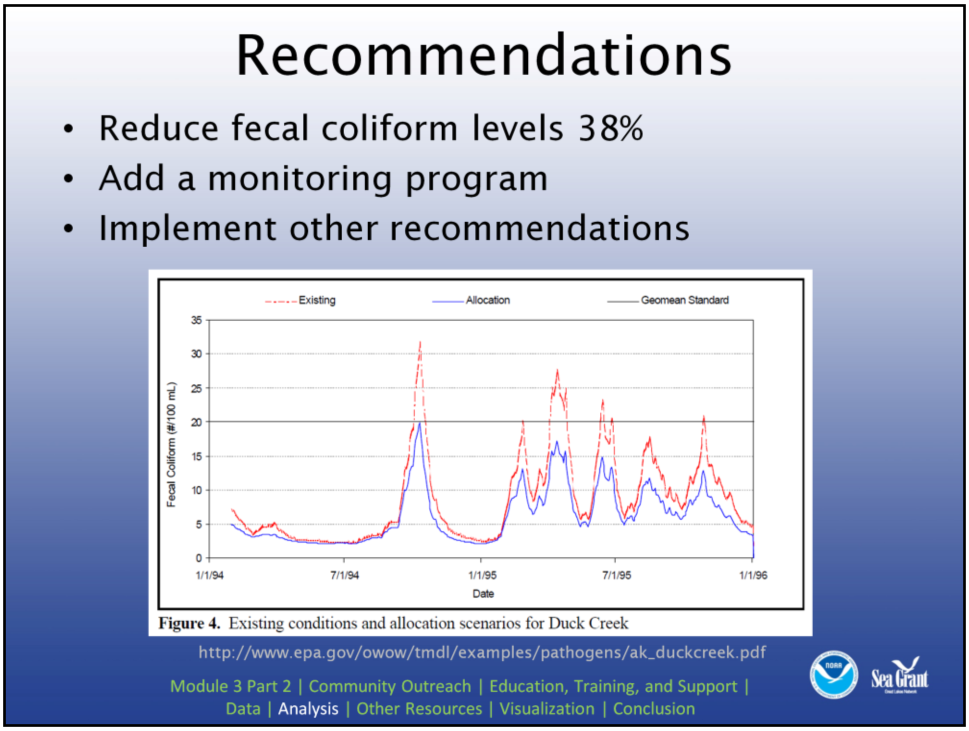
For this case, the EPA selected the SWMM model, because it can be used to (1)simulate urban runoff and (2) show the type and quantity of pollutants that are likely to be carried in the runoff. The SWMM model was used to establish a Total Maximum Daily Load (TMDL) for fecal coliform bacteria in the Duck Creek watershed. According to the EPA, TMDL is "a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards." So, SWMM was used to determine the maximum amount of fecal coliform bacteria that the watershed could manage. To do this, the model was first used to estimate the present concentration of fecal coliform bacteria in the Duck Creek, and then was used to determine an appropriate level of fecal coliform bacteria that could be safely assimilated by Duck Creek in order to meet water quality and safety standards.

Source citations:

- Environmental Protection Agency. September 2008. "National Pollutant Discharge Elimination System (NPDES)". http://cfpub.epa.gov/npdes/stormwater/tmdl.cfm
- Environmental Protection Agency. 2000. *Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in the Waters of Duck Creek in Mendenhall Valley, Alaska.* http://www.epa.gov/owow/tmdl/examples/pathogens/ak_duckcreek.pdf (accessed December 23, 2010)

Image citation:

RiverSides. 2009. "Urban Runoff." *Toronto Homeowner's Guide to Rainfall*. http://www.riversides.org/rainguide/riversides_hgr.php?cat=1&page=38 (accessed December 23, 2010)



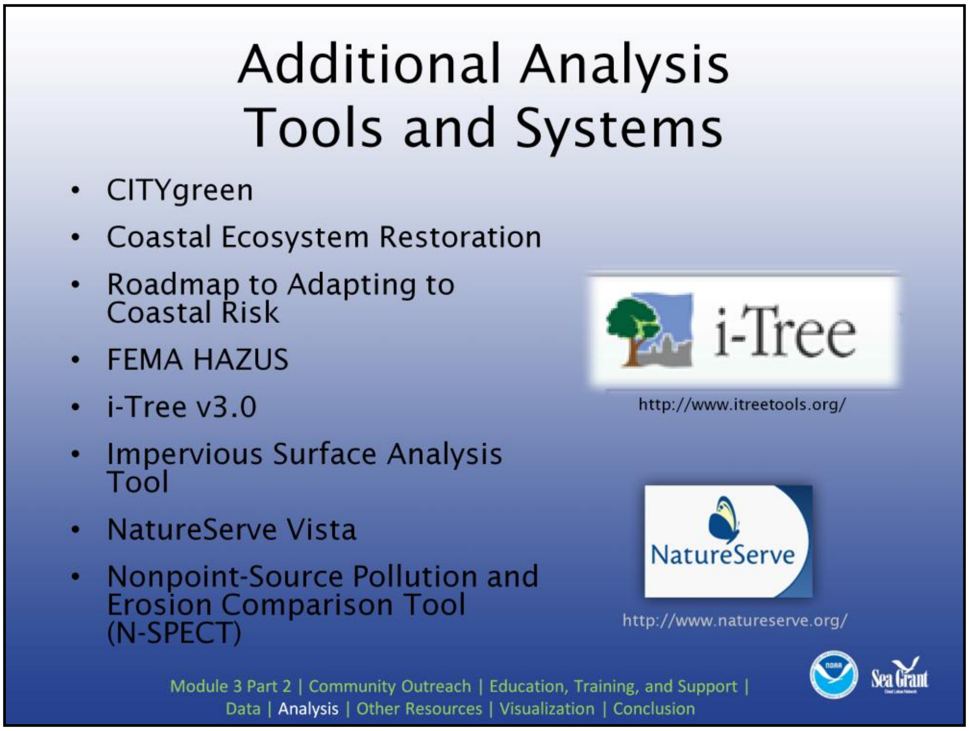
The study found that there needed to be a 38% reduction in fecal coliform levels in order for the levels to be returned to acceptable concentrations. As one step in reaching this goal, the EPA also suggested that a monitoring program be formed in order to record the levels of fecal coliform in the watershed and monitor changes—hopefully, improvements—in water quality.

The report also made several other recommendations to improve the water quality in Duck Creek:

- Increase public participation and education in order to raise awareness about water quality issues in the watershed.
- Continue existing efforts and local plans to improve conditions in the watershed and to improve fish habitat.
- Developed flow allocation to improve fish habitat and water quality.
- Create a stormwater management plan.

Check out the EPA website (http://water.epa.gov/scitech/datait/models/basins/bsnsdocs.cfm#hspf) for more examples of BASINS applications, including Great Lakes examples.

Image citation:
Environmental Protection Agency. 2000. *Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in the Waters of Duck Creek in Mendenhall Valley, Alaska.* http://www.epa.gov/owow/tmdl/examples/pathogens/ak_duckcreek.pdf (accessed December 23, 2010)

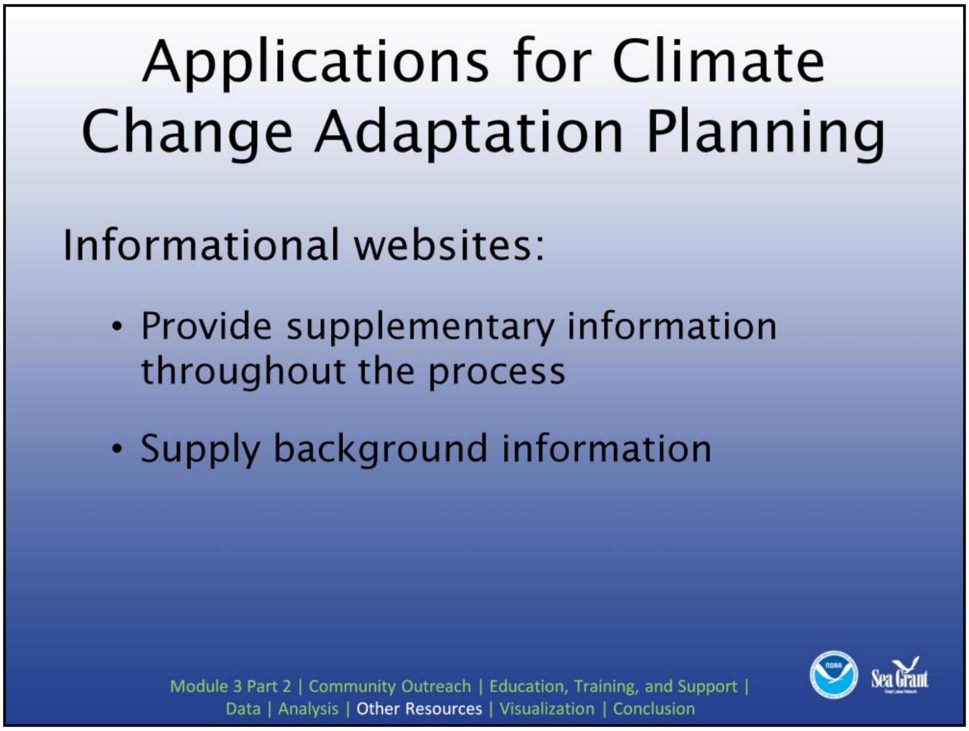


If you're interested in learning more about available Analysis Tools and Systems, check out your handout for a more detailed description of the tools on this slide.

Image citations:

- United States Forestry Service."i-Tree." http://www.itreetools.org/ (accessed December 23, 2010)
- NatureServe. "NatureServe: A Network Connection Science with Conservation." http://www.natureserve.org/ (accessed December 23, 2010)

The fifth category of tools is called "Other Informational Websites," which are websites that provide additional information on climate change and climate change adaptation planning topics.



This group of tools and websites help address specific climate change adaptation planning needs that are not addressed in the other tool categories. There is a wide range of resources that include information on topics such as hydrology, climate change, and endangered species. This category does not necessarily fit into a specific step of climate change adaption planning; rather, these resources are meant to provide supplemental information and support throughout the whole process.

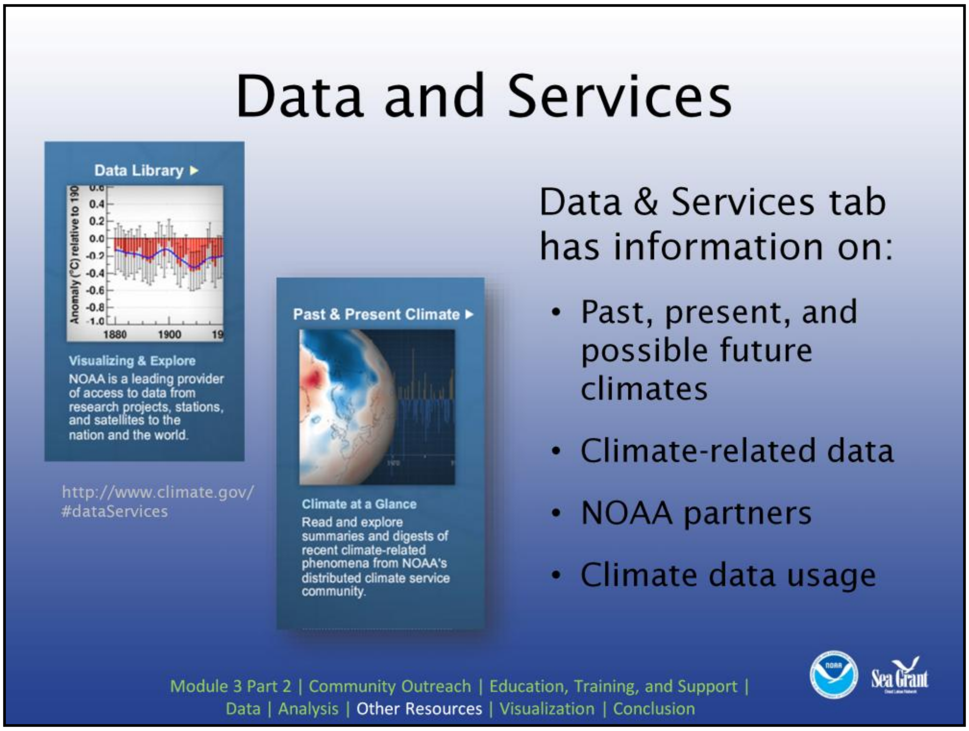
NOAA Climate Services Portal is one example of an informational website that can be useful for adaptation planning.

Image citation:
NOAA Climate Services. "NOAA Climate Services." http://www.climate.gov/#climateWatch (accessed December 23, 2010)

NOAA Climate Services Portal Factsheet

- **Description:** Website provides information related to climate change
- **Cost:** None
- **Training/Time Requirements:** None
- **Other Requirements/Notes:** None

This website offers climate information—ranging from data and services to educational materials and information. It is free to use and does not have any training requirements.



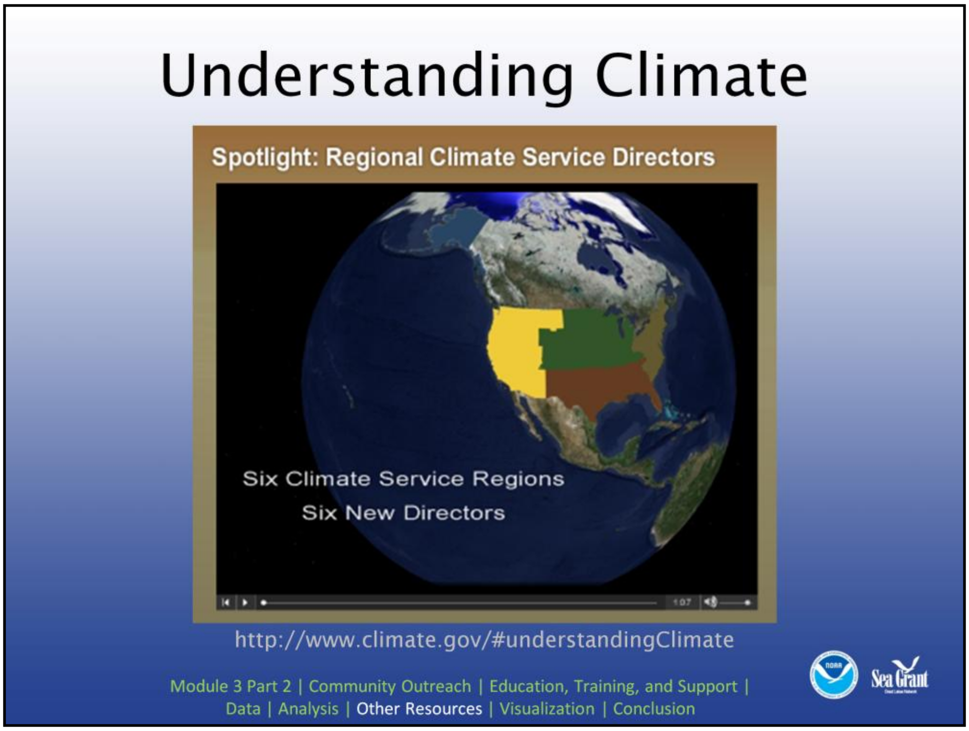
The NOAA Climate Services Portal has four main informational tabs on the website. The first tab is for the ClimateWatch magazine, and users can browse articles, videos, and images related to the magazine. The second tablinks users to a wide range of data and services, including information on:

- Past, present, and anticipated future climates
- Climate-related data and examples on how to use climate data
- NOAA partners, including regional and state climate experts

The next two tabs are discussed on the following slides.

Source citation:
NOAA Climate Services. “Data & Services.”
http://www.climate.gov/#dataServices (accessed December 23, 2010)

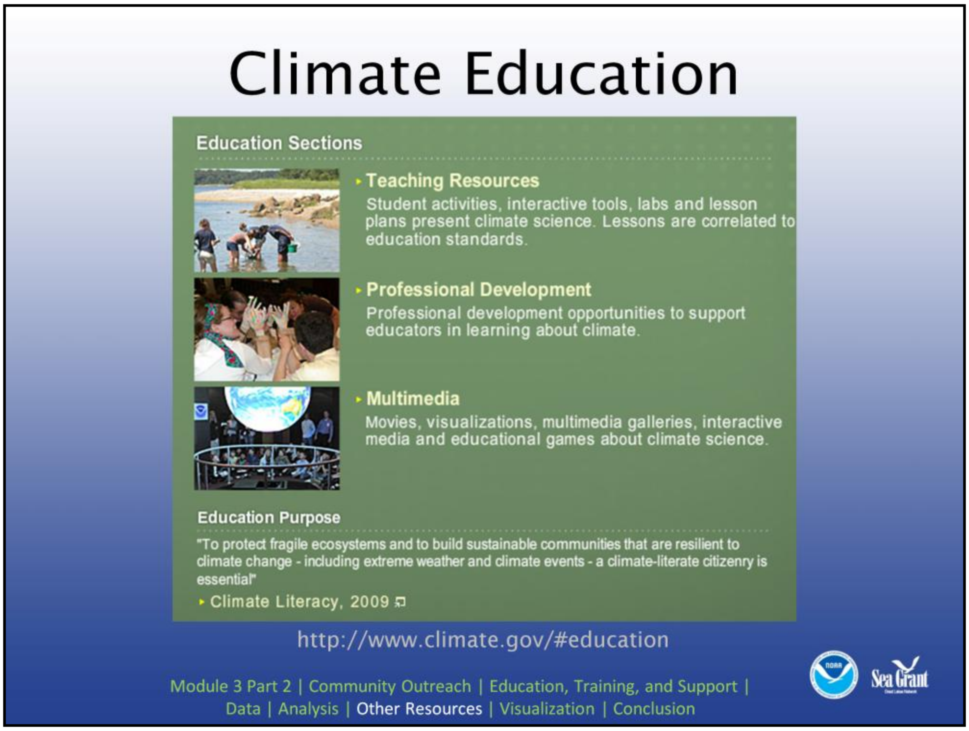
Image citation:
NOAA Climate Services. “Data & Services.”
http://www.climate.gov/#dataServices (accessed December 23, 2010)



The third tab is called "Understanding Climate," and it directs users to information and resources related to climate change. There are links to assessment reports on the climateand climate factsheets. This portion of the website also provides more information on the six NOAA climate service regions.

Source citation:
NOAA Climate Services. "Understanding Climate." http://www.climate.gov/#understandingClimate (accessed December 23, 2010)

Image citation:
NOAA Climate Services. "Understanding Climate." http://www.climate.gov/#understandingClimate (accessed December 23, 2010)

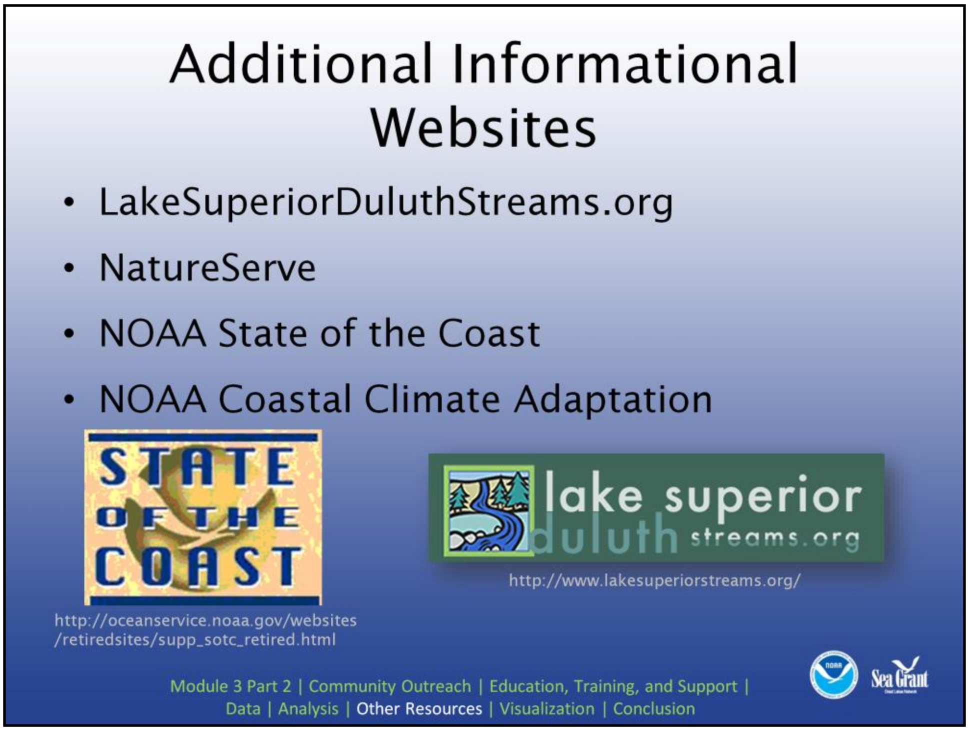


The final tab directs users to valuable educational materials related to climate change. Various resources are available for teachers to use in the classroom, and there is also information on professional development for educators. There is also a resource that provides multimedia educational resources.

Source citation:
NOAA Climate Services. "Education."
http://www.climate.gov/#education (accessed December 23, 2010)

Image citation:
NOAA Climate Services. "Education."
http://www.climate.gov/#education (accessed December 23, 2010)

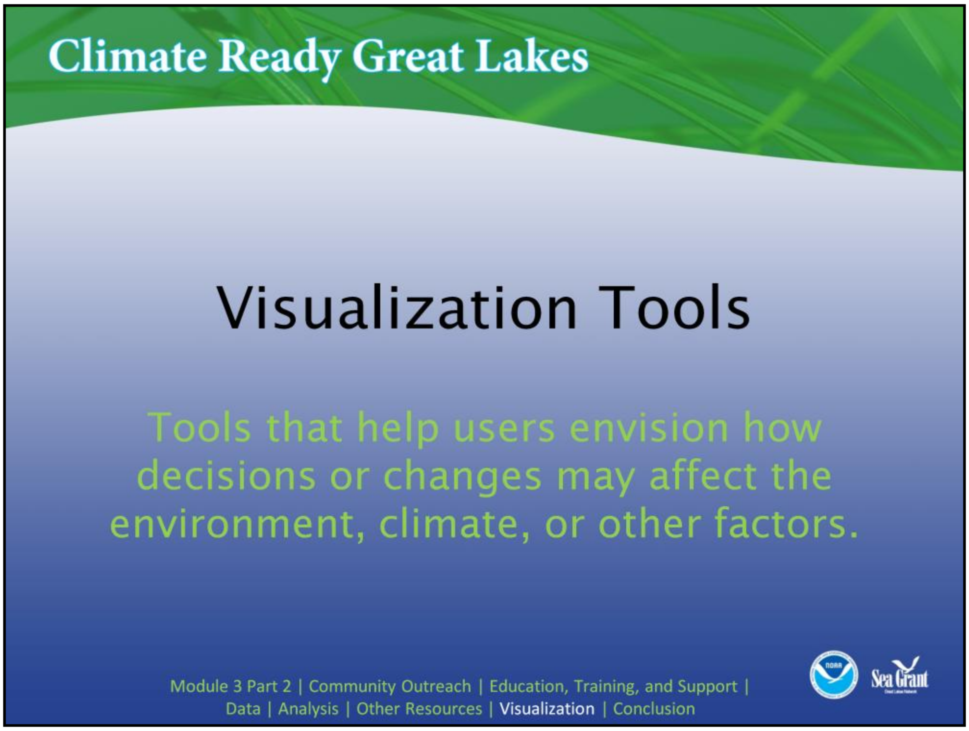
So, how can the NOAA Climate Services Portal be useful for climate change adaptation planning? The website can be used to find educational materials on climate change, which can be used to educate the public to gain support for climate change adaptation planning.Also, decision makers can use the website in order to (1) learn more about climate change and (2) get in touch with people who can act as resources in the climate change adaptation planning process. This tool does not necessarily fit into a specific part of adaptation planning process—instead, it is best utilized as an informational resource and community outreach tool throughout the process.



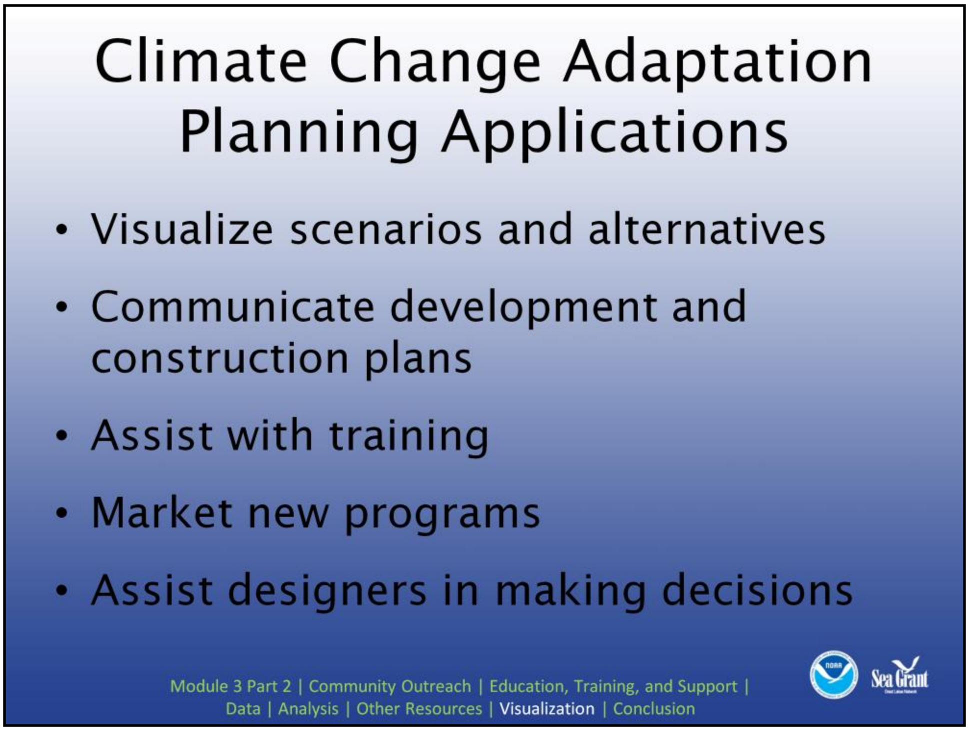
If you are interested in finding additional informational websites, please see the handout for a list websites that can be useful for climate change adaptation planning.

Image citations:

- Environmental Protection Agency, NOAA, and Minnesota's Lake Superior Coastal Program. "Lake Superior Duluth Streams.org." http://www.lakesuperiorstreams.org/
- National Ocean Service. "NOAA State of the Coast." http://oceanservice.noaa.gov/websites/retiredsites/supp_sotc_retired.html (accessed December 23, 2010)



Visualization tools help users envision how decisions or changes may affect the environment, climate, or other factors.

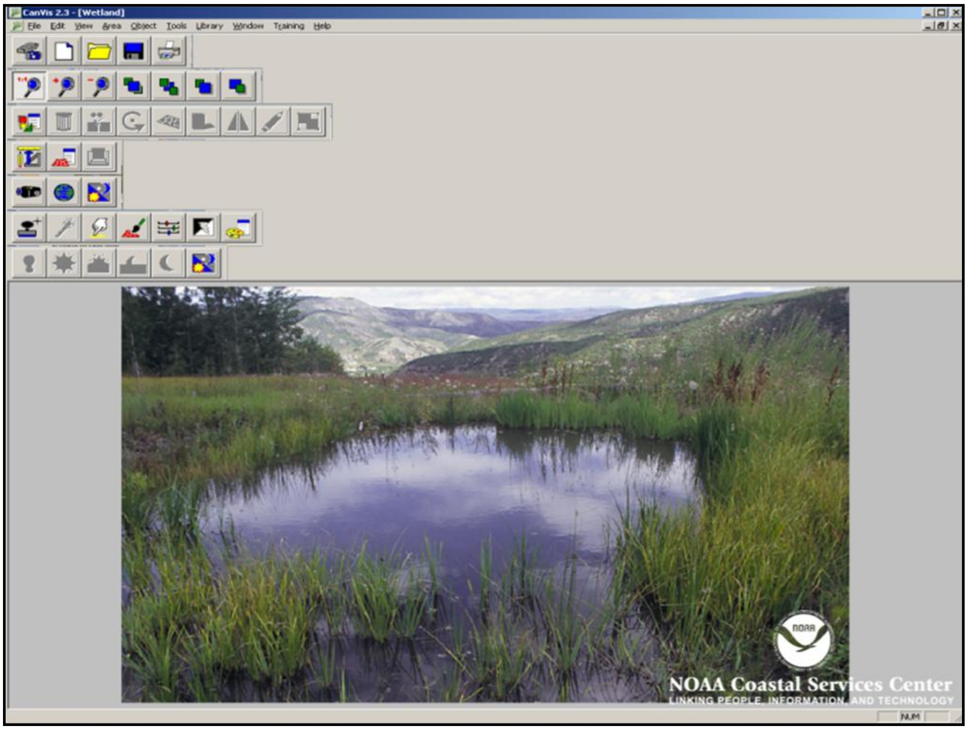


Visualization tools represent data graphically and can make the information easier to understand. This is key in adaption planning, because it allows information to be shared with the public, internal partners, and external partners. This capability can be valuable at any point in the planning process when communication is essential.

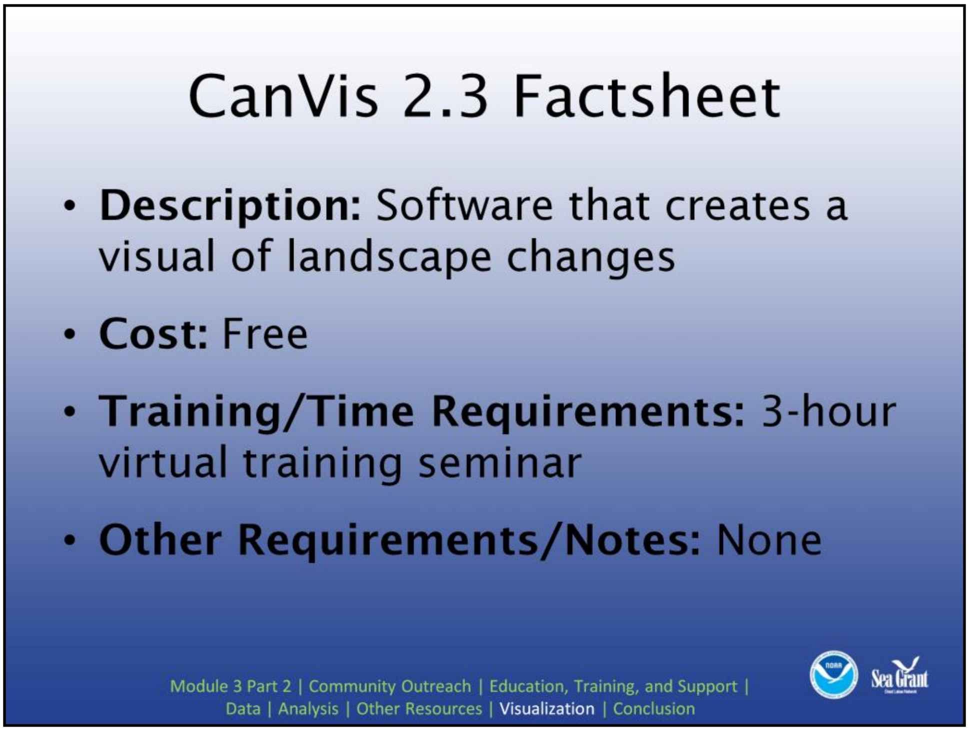
Applications include assisting with image editing to present alternatives and receive feedback, communicating plans, providing construction aid to contractors, assisting with training, marketing new programs, and assisting designers in making decisions.

Citation:

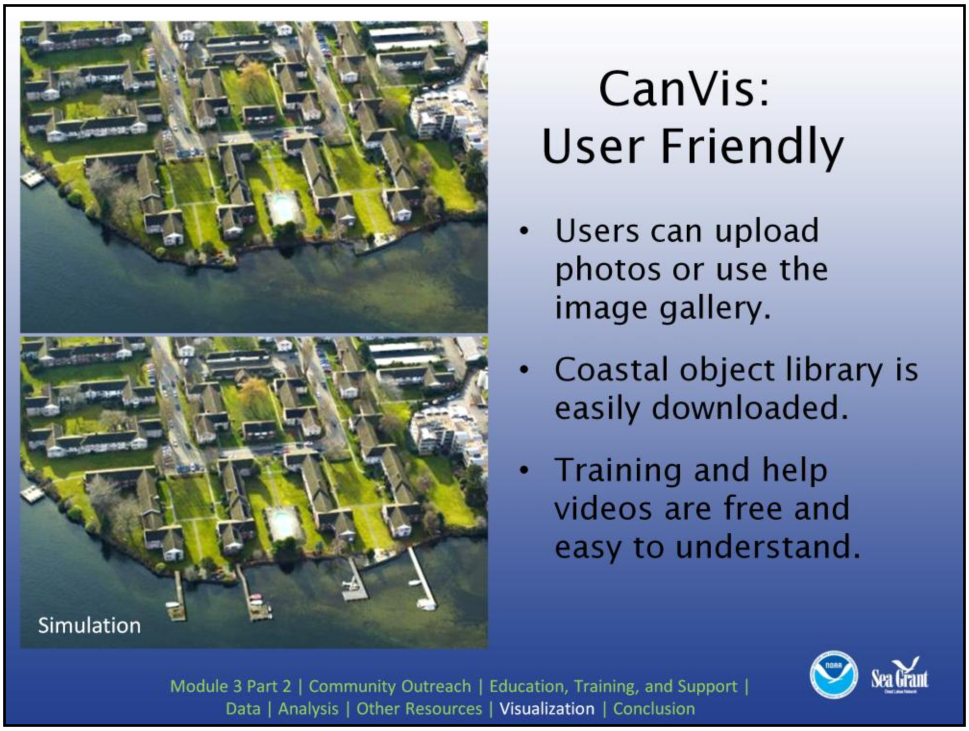
USDA National Agroforestry Center. http://www.unl.edu/nac/simulation/examples.htm (accessed December 28, 2010)



A screen shot of the CanVis program's interface; the photo was selected from the CanVis image library.



CanVis is a NOAA Digital Coastsoftware program that creates a visual display of landscape changes. Images help users determine potential impacts of a project. The cost is free and the it requires a three-hour virtual training seminar. Training is conducted via WebEx, which requires internet, phone, and WebEx software.



CanVis can help users visualize different development scenarios. In this example, different shoreline development scenarios in Seattle, Washington, are displayed.

CanVis is intuitive, visual, and lends itself to users who have little experience with planning software. Users can upload their own photos, and training and help videos are free and easy to understand.

Image citation:

NOAA Coastal Services Center

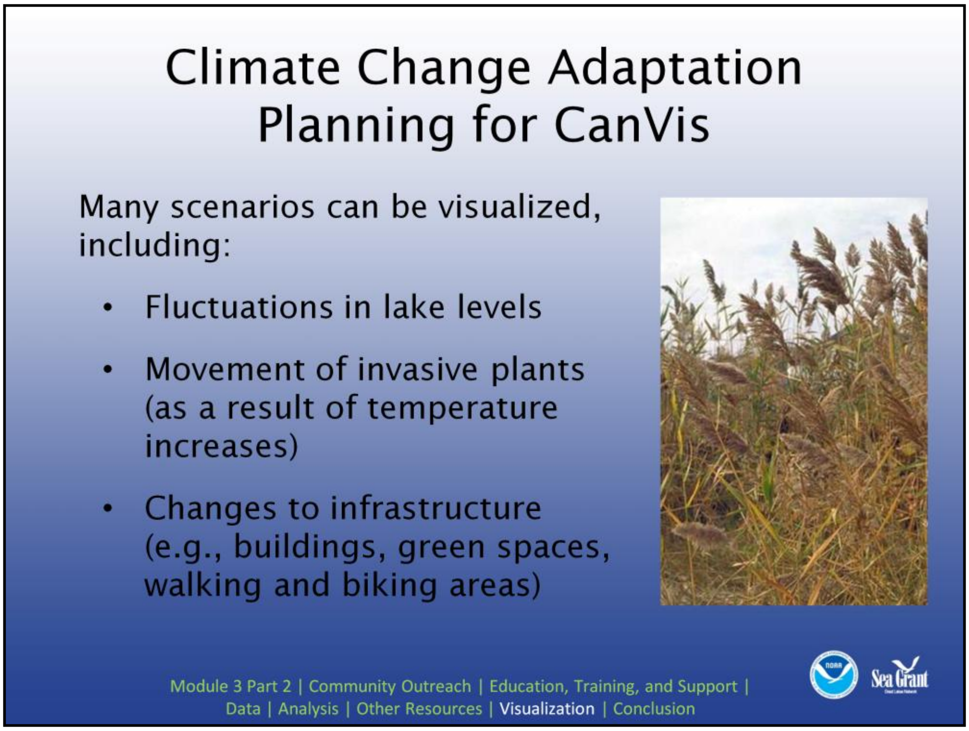
Caveats about CanVis

- Mark altered photos
- Be aware that this is not a modeling program
- Use credible images and information
- Keep photos in larger context

CanVis is a visualization software that allows you to alter photos; insert the word “Simulation” into the corner of the image to make sure that viewers know when photos have been altered. CanVis is not a modeling program; use images based off of information generated from reliable models, reports, or experts. A one-shot photograph may manipulate the perception of the area, so be sure to put the photo in context—especially when using certain angles.

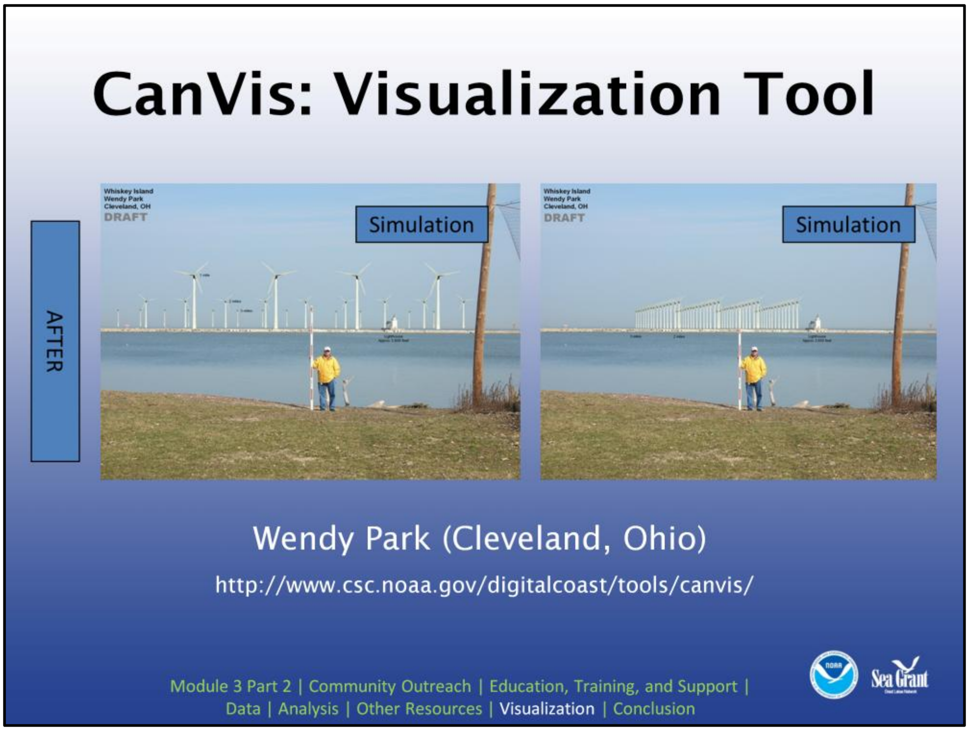
Image citation:

NOAA Coastal Services Center



CanVis helps to visualize many possible Great Lakes climate change scenarios. For example, the software can show fluctuations in lake levels, movement of invasive plants, addition of off-shore wind turbines, and infrastructure changes. These specific impacts are explained further in Module 1.

Image citation:
National Park Service. “Plants.” http://www.nps.gov/gate/naturescience/plants.htm (accessed on December 28, 2010)

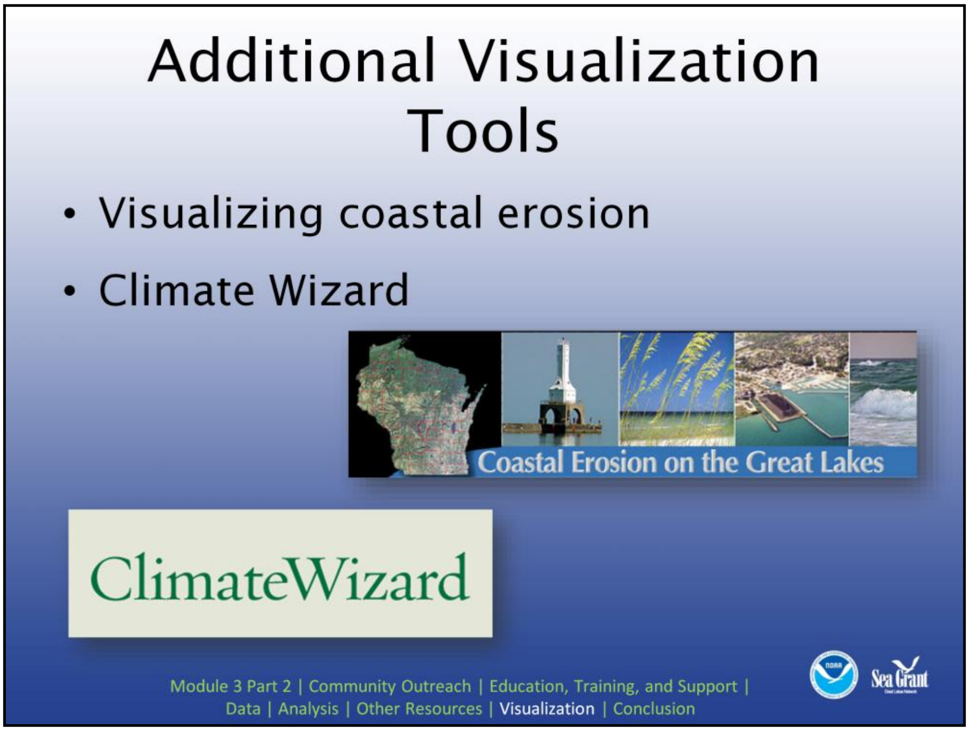


In this example, CanVis was used to alter a photo of Wendy Park in Cleveland, Ohio. The photo simulations show two different scenarios of possible locations for off-shore wind turbines.

CanVis software can be easily accessed/downloaded from NOAA's Digital Coast web site.

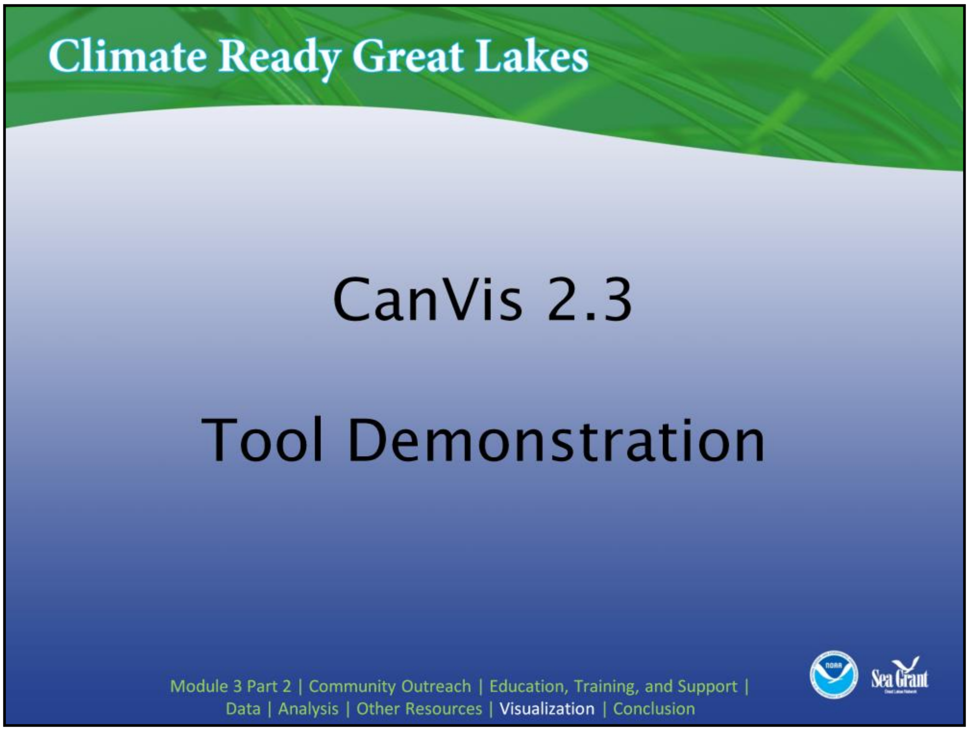
Image citation:

Coastal Services Center. "CanVis." http://www.csc.noaa.gov/digitalcoast/tools/canvis/ (accessed December 28, 2010)



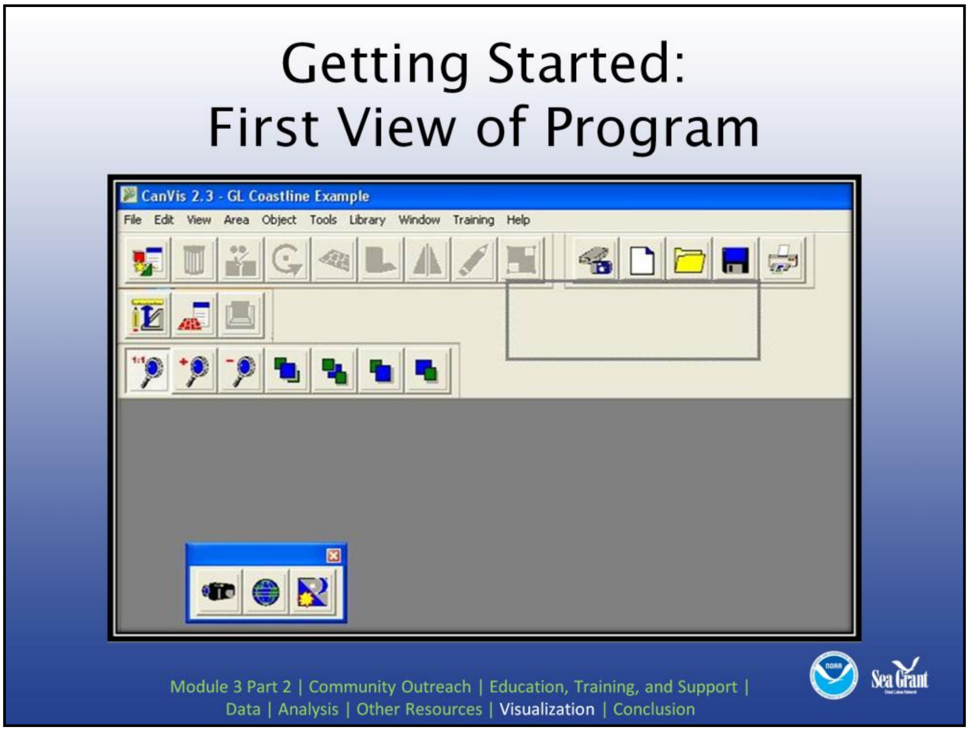
Here is another available visualization tool that can be applied to Great Lakes areas. If you are interested in learning more about this option, please see the handout.

Image citations:
The Nature Conservancy. "Climate Wizard." http://www.climatewizard.org/ (accessed December 28, 2010)
University of Wisconsin. "Coastal Erosion on the Great Lakes," http://www.geography.wisc.edu/coastal/ (accessed December 28, 2010)



The following slides are an example of the application of CanVis to Great Lakes Coastal communities. By the end of these slides, you will be familiar with the basic functions of CanVis and possible applications to adaptation planning.

To demonstrate the tool, we will walk training participants through a series of CanVis screenshots that depict actual use of the tool. We are using a hypothetical example to illustrate three separate events that could occur in the Great Lakes. This demonstration—which is only for learning purposes—uses a strip of the Lake Superior shoreline. The slides illustrate the inclusion of off-shore wind turbines, fluctuations in shoreline water level, and clearing trees for development.

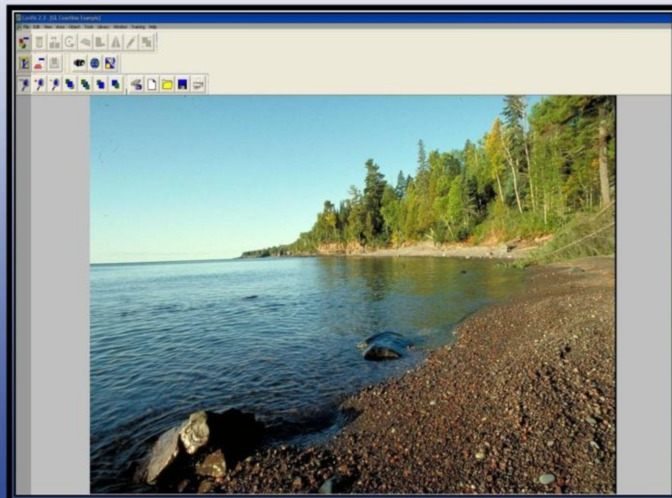


This slide shows the CanVis interface.
Toolbars allow you to design and create a scene.

You can use a photo from the CanVis library or import a photo of your own. In this case, we downloaded a photo from EPA's Great Lakes image library.

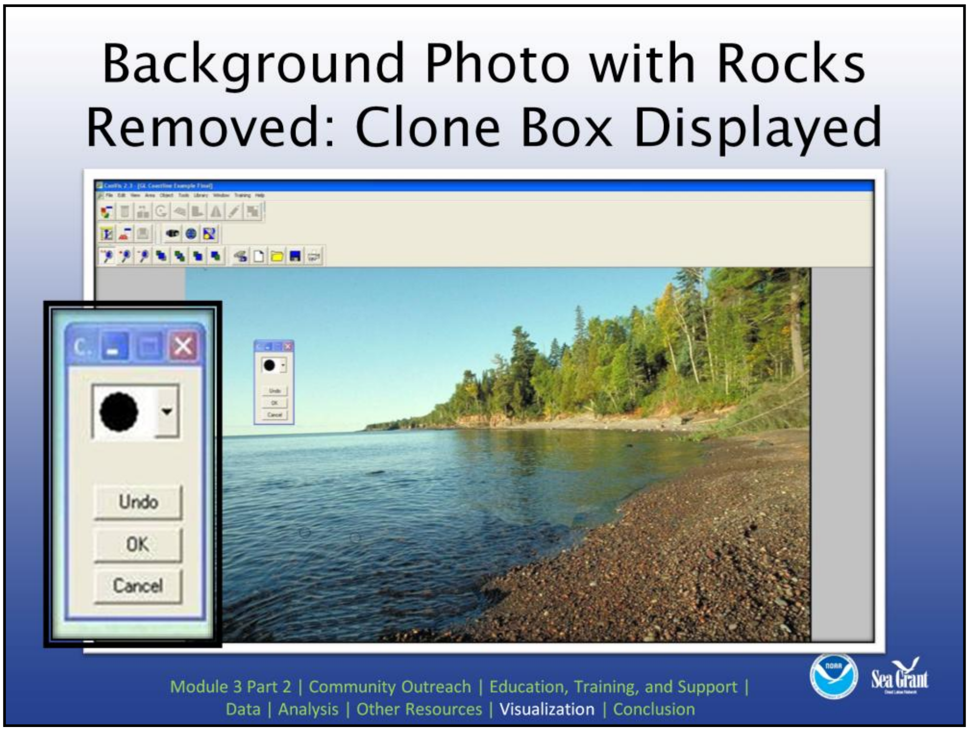
Image citation:
Environmental Protection Agency, Great Lakes National Program Office. Image Collection. "North Shore beach of Lake Superior, Lake Superior, Minnesota." Minnesota Extension Service, Dave Hansen, Sep. 1992. http://www.epa.gov/greatlakes/image/

Photo Alterations

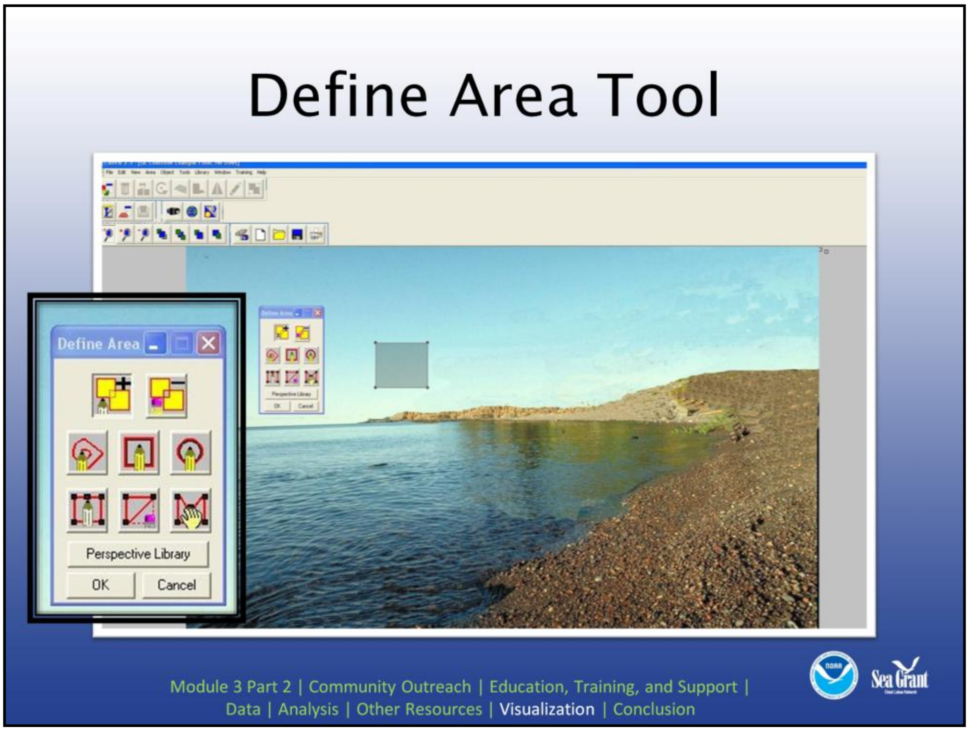


Module 3 Part 2 | Community Outreach | Education, Training, and Support | Data | Analysis | Other Resources | Visualization | Conclusion

You can add new objects to the photo, and you can also remove objects already in the photo. For this tutorial, the rocks in the foreground are removed along with the trees in the upper right corner.



The clone tool can be used to copy one area of the photo and paste it over another area. For example, you would use this tool to cover objects with existing groundcover. Here, the rocks in the foreground were “removed” from the image by copying a water image and then pasting it over the rocks.

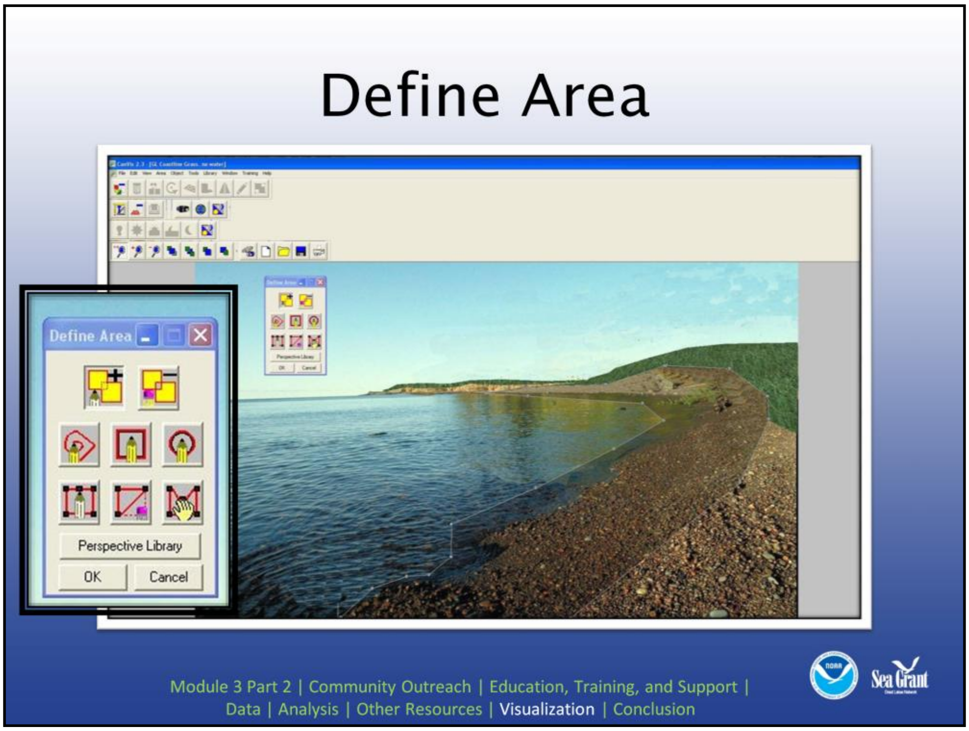


The Define Area tool is another way to cover objects in the background photo. In this example, the tool was used to specify a square area of the sky, which was then copied over the trees in the upper right corner to remove them from the picture.

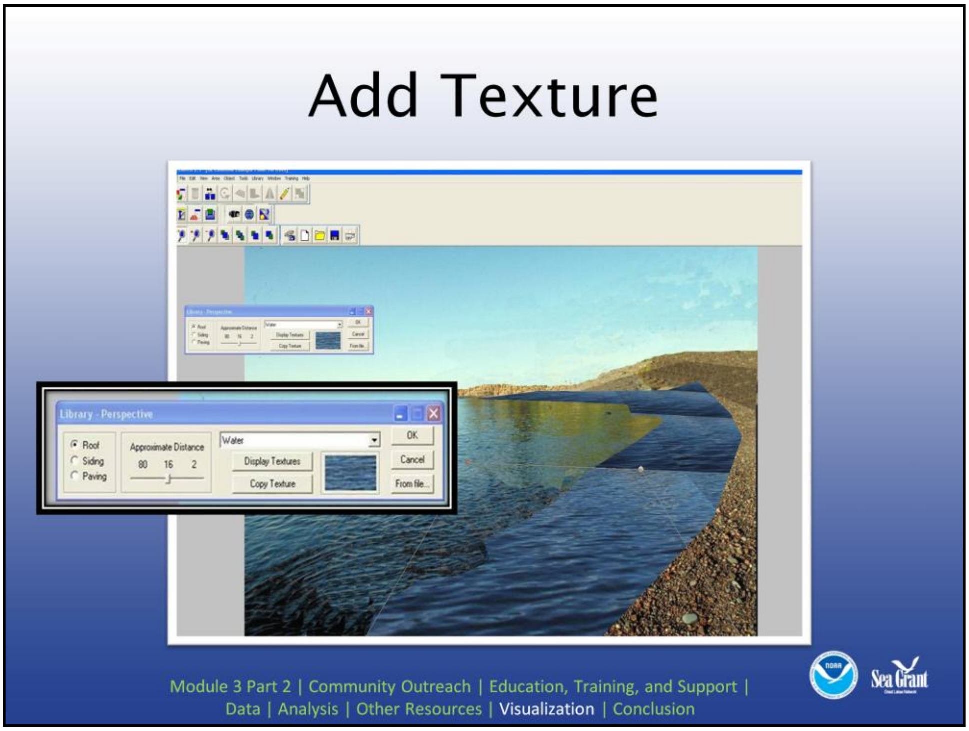
Textures

1. Identify the areas that need to be a different texture (such as pavers, groundcover, and sod)
2. Complete four steps in CanVis:
   - Define an area
   - Fill with texture
   - Add perspective
   - Adjust scale

Next, youcan identify the areas in the photo that need to be a different texture. These include things like pavers, groundcover, and sod.

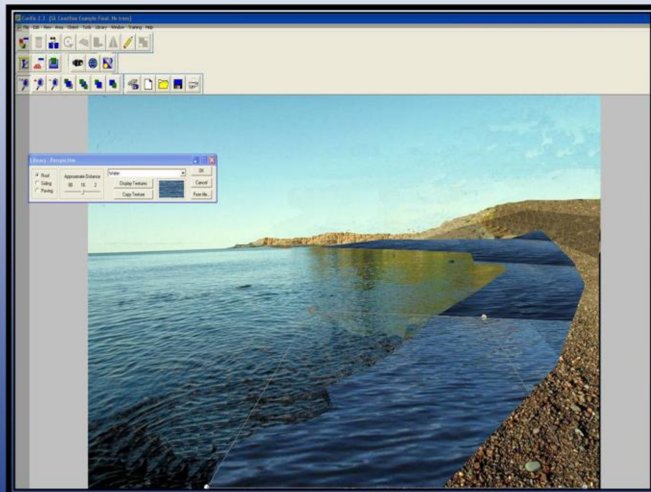


The software allows you to define the dimensions of an area to cover. Once an area is selected, the area will turn grey.



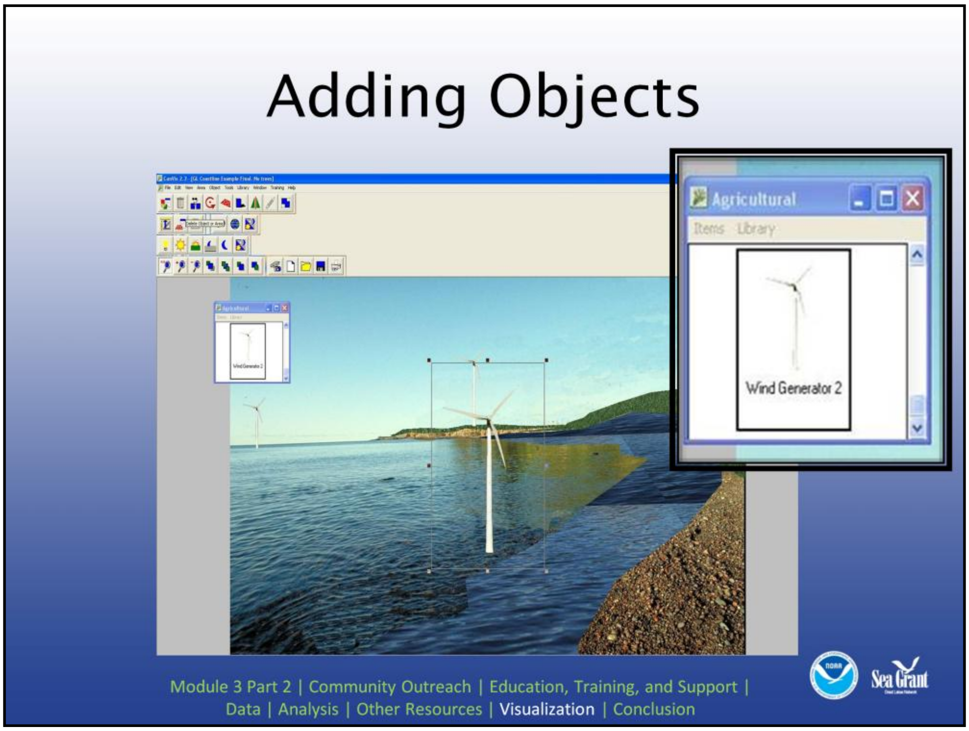
The texture library allows you to select from a number of different textures: water, brick and stucco, pavers, ground and groundcover, roofing and siding, and stone.

Perspective and Scale



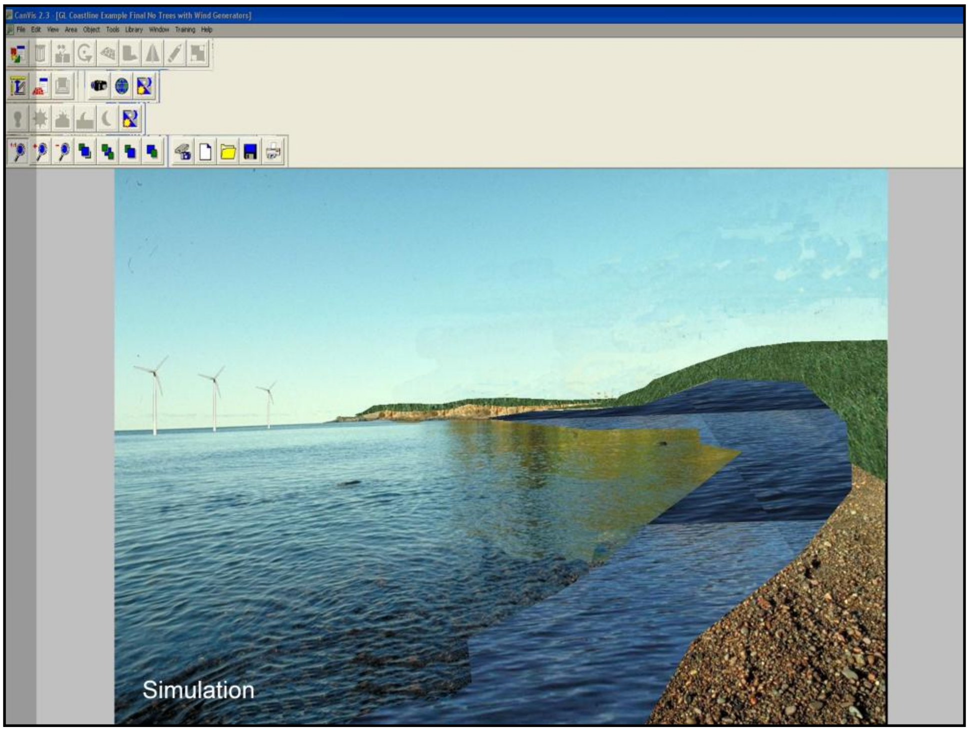
Module 3 Part 2 | Community Outreach | Education, Training, and Support | Data | Analysis | Other Resources | Visualization | Conclusion

Perspective and scale can be altered to make the newly textured area look like it is going off into the distance.

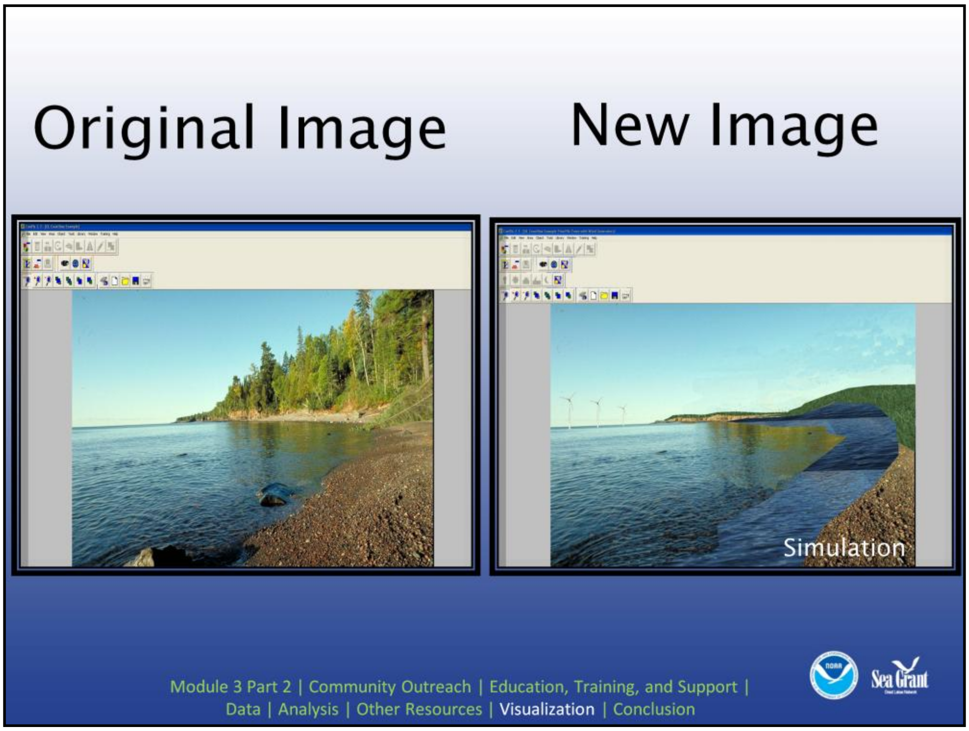


CanVis' object library includes many categories of objects: agricultural, desert and drought, drawing aids, flowers, grass and groundcover, groupings, hardscapes, people, shrubs, trees, vehicles, vines and climbers, wetland plants, and Wildlife.
Objects can be rotated, flipped, and altered.

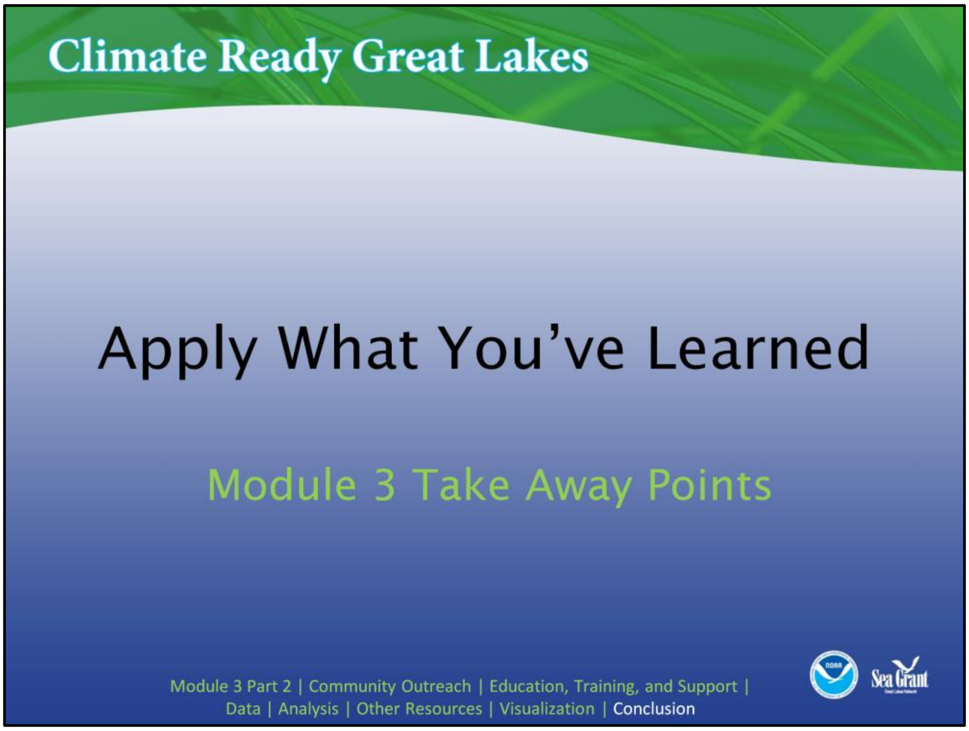
Additional CanVis objects are available for download, including alternative energy, boats, coastal vegetation, houses, parks and urban areas, satellite and aerial, symbols, transportation, and walls and buffers. TheIntegration and Application Network has over 2,000 coastal objects available for download. Additional objects can be downloaded from http://www.csc.noaa.gov/digitalcoast/tools/canvis/download.html.



This finished product is an example of what the software is capable of doing. Again, precise modeling and scale will be needed for accurate reflections of climate impacts.



At left, the original image. At right, the finished product created in CanVis.



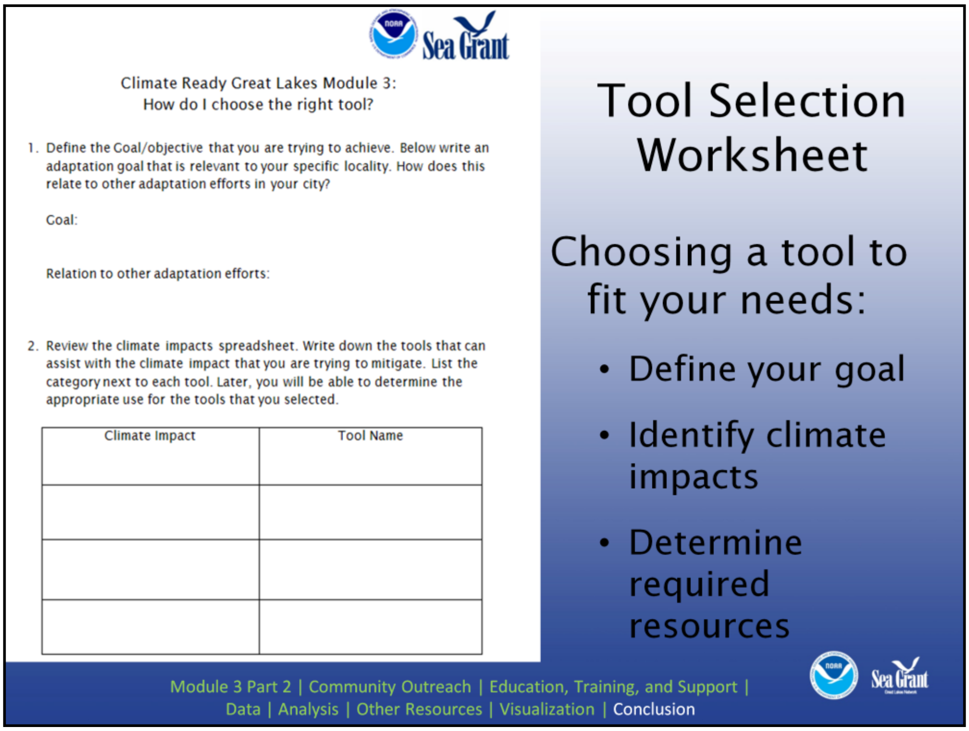
The information presented in this module should help you get started on choosing and using tools for your own community's adaptation plan.

With the information that you've learned in this module, you should now be equipped to (1) start choosing appropriate tools for your community and (2) find resources and information that can help you use the tools effectively.

This module also highlighted key climate change adaptation tools available to Great Lakes' communities; some of those tools may be directly applicable to your community's needs and available resources. See the handout for more details on the various climate change adaptation planning tools; use the contacts listed there to find out more information.

Remember that there are two other modules available to help your community adapt to climate change. Module 1 can help you learn more about anticipated climate change impacts, and Module 2 can help you learn to develop an adaptation plan for your community.

Image citation:
Environmental Protection Agency. "Visualizing the Great Lakes."
http://www.epa.gov/greatlakes/image/vbig/8.jpg (accessed December 23, 2010)



Now that you've completed the Module 3 training, you can use this worksheet to apply this knowledge to climate change adaptation planning to your area.

	TOOL APPLICATIONS	Stormwater Management	Flood Hazard Reduction	Drought	Building/ City Infrastructure	Shoreline Infrastructure	Transportation	Energy	UHI/Human Health	Air and Water Quality	Ecosystem Resilience
CATEGORY OF TOOL	**TOOL NAME**	X	X	X	X	X	X	X	X	X	X
Community Outreach	Building Coast-Smart Communities: A Role Play Exercise	X	X	X	X	X	X	X	X	X	X
Community Outreach	Environmental Planning for Small Communities (TRILOGY)	X	X	X	X	X	X	X	X	X	X
Community Outreach	Green Communities	X	X	X	X	X	X	X	X	X	X
Education, Training and Support	Climate Adaptation Knowledge Exchange (CAKE)	X	X	X	X	X	X	X	X	X	X
Education, Training and Support	Climate Change in the Great Lakes: Starting a Public Discussion	X	X	X	X	X	X	X	X	X	X
Education, Training and Support	Digital Coast Coastal Inundation Toolkit		X		X	X					X
Education, Training and Support	Coastal Services Center Training	X	X	X	X	X	X		X		X
Education, Training and Support	Ecosystem Based Management Tools	X	X	X	X	X	X	X	X	X	X
Education, Training and Support	Great Lakes Weather and Climate	X	X	X							
Education, Training and Support	National Estuarine Research Reserve Training	X	X	X	X	X			X	X	X
Education, Training and Support	Sea Grant Training: Ohio State University Webinars									X	X
Data	Coastal Change Analysis Program Regional Land Cover				X					X	X
Data	Coastal County Snapshots		X		X						X
Data	Great Lakes Information Network	X	X	X	X	X	X	X	X	X	X
Data	Historical Maps and Charts	X	X	X	X	X	X	X	X	X	X
Data	MyEnvironment								X	X	
Data	New York Ocean and Great Lakes Atlas: Data Viewer	X	X	X	X	X	X	X	X	X	X
Data	NOAA Digital Coast	X	X	X	X	X	X	X	X	X	X
Data	NOS Data Explorer	X	X	X		X					X
Data	Ohio Coastal Atlas and GIS	X	X	X	X	X	X	X	X	X	X
Data	Wisconsin Coastal Atlas	X	X	X	X	X	X	X	X	X	X
Analysis	Better Assessment Science Integrating point and Non-point Sources (BASINS)	X	X	X						X	X
Analysis	CITYgreen	X	X		X			X	X	X	
Analysis	Coastal Ecosystem Restoration										X
Analysis	FEMA HAZUS		X		X						
Analysis	Habitat Priority Planner				X						X
Analysis	i-Tree v3.0	X	X		X					X	X
Analysis	Impervious Surface Analysis Tool	X	X							X	X
Analysis	NatureServe Vista				X		X	X			X
Analysis	Nonpoint-Source Pollution and Erosion Comparison Tool (NSPECT)	X	X							X	X
Analysis	Roadmap for Adapting to Coastal Risk										
Informational	Lake Superior Duluth Streams.org	X	X							X	X
Informational	NatureServe Website										X
Informational	NOAA Coastal Climate Adaptation	X	X	X	X	X	X		X		X
Informational	NOAA Coastal Services Center How-to-Guides	X	X		X	X					X
Informational	NOAA Climate Services Portal	X	X	X	X	X	X	X	X	X	X
Informational	NOAA State of the Coast				X	X				X	X
Visualization	CanVis	X	X	X	X	X	X	X	X	X	X
Visualization	Climate Wizard	X	X	X	X	X	X	X	X	X	X
Visualization	Visualizing Coastal Erosion					X					X

Great Lakes Climate Adaptation Tool Handout
January 2011

Introduction

This handout is a compilation of tools and resources that can provide assistance to Great Lakes coastal communities in their climate change adaptation efforts. Each resource or tool was selected based upon potential applicability to the Great Lakes region and usefulness in climate change adaptation. City planners and other similar professionals can use these tools and resources to facilitate action on numerous levels. A few applications for the tools include decision-making support, improving communication with the public, understanding risk and vulnerability to various climate change scenarios as well as predicting future scenarios for planning and goal implementation.

Tool complexity and application varies but all can be adjusted to fit Great Lakes communities. Some tools are computer software programs while others are methods, databases or web applications. The tools are broken down into six categories for easy reference: Community Outreach Tools; Education, Training, and Support Tools; Data Websites; Other Informational Websites; Analysis Tools and Systems; Visualization Tools. There is also supplementary contact information listed at the end of the handout with information on state and regional climatologists and climatology offices.

Community Outreach Tools

In general, community outreach tools help decision makers communicate with the public and interpret policy/decision making processes so that solutions are accessible to the public at large. The following Role playing tool facilitates climate change discussions among stakeholders to show the varying perspectives from many different sectors (business owners, environmental professionals, politicians, and others). Other tools in this section assist with various planning challenges. These tools are applicable throughout the climate change adaptation planning process, but should be used heavily at the beginning of the process to gain community support.

- **Building Coast- Smart Communities: A Role Play Exercise**
  http://maryland.coastsmart.org
  This tool is a half-day role-play exercise that encouraged participants to discuss climate change adaptation options and the challenges associated with climate change. It is targeted towards policy and Maryland in particular, but can be adapted for other areas. Materials can be downloaded for free from the above listed website.
  Contact: For more information about the role-play exercise and the Coast-Smart Initiative, please send an email to info@coastsmart.org or call the Chesapeake & Coastal Program at the Maryland Department of Natural Resources at (410) 260-8743 or David Plumb at the Consensus Building Institute at (617) 844-1128

Keywords: Role-play; Climate change discussion; Maryland; Policy
Cost: None
Training/Time Requirements: ½ day course
Other Requirements/Notes: None

- **Environmental Planning for Small Communities (TRILOGY)**
  http://www.purdue.edu/envirosoft/trilogy.html
  This tool is intended to assist communities, from small to medium in size, with the range of environmental issues they may face. Major components include: Environmental laws and regulations; Self-assessment; Planning and comparative risk analysis; Financial tools and financial self-analysis; Case studies; Contact and information directory.
  Contact: Users can fill out a question form at:
  http://www.purdue.edu/envirosoft/comment.html
  Keywords: Small communities; Policy and planning
  Cost: Free
  Training/Time: Varies
  Other Requirements/Notes: It is necessary that users have a Windows 3.1 or Windows 95 or higher operating systems, and that they have at least 55 Mb free on their hard drive.

- **Green Communities**
  http://www.epa.gov/greenkit/index.htm
  This tool helps guide communities in creating a planning framework to help reduce environmental impacts. There are 5-steps in the process: 1. Community Assessment; 2. Trend Analysis; 3. Vision Statement; 4. Sustainable Action Plans; 5. Implementation. The website offers background information on the processes, displays case studies, and offers advice on how to get started.
  Contact: Francesca Di Cosmo, dicosmo.francesca@epa.gov
  Keywords: Planning and policy; Green infrastructure
  Cost: Free
  Training/Time: Varies
  Other Requirements/Notes: None

Education, Training, and Support Tools

This category links education, training, and support tools. Some tools offer information on climate change, which can be used as educational resources for decision makers or for outreach. Some tools offer training on many topics, including managing coastal areas and GeoSpatial technology. Finally, some tools are databases that can help users find additional tools for adaptation planning. Education, training, and support tools should be utilized both early on and throughout in the adaptation planning process.

- **Climate Adaptation Knowledge Exchange (CAKE)**
  http://www.cakex.org/tools
  This website lists climate change related tools and updates its site when new tools become available. Other information is available such as case studies, a virtual library, and a directory related to climate change information and adaptation efforts.
  Contact: EcoAdapt (206-201-3834)

Users can also contact the CAKE website with questions at:
http://www.cakex.org/contact/information_request
Keywords: Tool acquisition; Case studies
Cost: None (time to search website)
Training/Time Requirements: None (time to search website/learn about tools)
Other Requirements/Notes: None

- **Climate Change in the Great Lakes Region**
  http://seagrant.wisc.edu/climatechange/
  This website provides information and resources on the Climate Change in the Great Lakes Region: Starting a Public Discussion seminars that were held between March September 2007. Available on the website is an 80-page summary report and DVD of the seminar that goes over the seminar topics: What is known about climate change in the Great Lakes, What is predicted to occur with climate change, and Measures that can be taken to adapt to climate change impacts. Users can also view PDF summaries, powerpoints, and videos of each individual seminar by clicking on "The Seminars" tab in the table of contents.
  Contacts: David Hart, dhart@aqua.wisc.edu
  Keywords: Developing an adaptation plan; Background information
  Cost: None for web-based PDF; $13.50 for a printed copy; $5 for a DVD copy of the seminar
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **Coastal Inundation Toolkit**
  http://www.csc.noaa.gov/digitalcoast/inundation
  This website offers various resources that assist in dealing with coastal inundation events that occur when water covers land that is normally dry. There are six different categories users can choose from: "Understand (background information on the topic); Identify (discover potential impacts in your community); Maps (use maps to visualize the process); Assess (configure your community's risk and vulnerabilities); Communicate (learn how to communicate what you have uncovered to your community); Discover (examine case studies on how communities are dealing with this issue)."
  Contact: Doug Marcy, Doug.Marcy@noaa.gov
  Users can also submit questions at the following website:
  http://www.csc.noaa.gov/digitalcoast/feedback.html
  Keywords: Coastal inundation; Background information
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **Coastal Services Center Training**
  http://www.csc.noaa.gov/training
  This website provides information on a number of online modules and in-person training courses. Training opportunities include GeoSpatial Technology Courses and Coastal Management Courses. Process Skills Courses are also available including: 1. Negotiating for Coastal Resources; 2. Project Design and Evaluation; 3. Public Issues and Conflict Management; 4. Planning for

Meaningful Evaluation.   Several online courses are also available: 1. Public Trust Doctrine; 2. Survival Skills for Coastal Resource Managers ; 3. Web Content Design and Evaluation; 4. Conducting Needs Assessments.
Contact: Varies, depending on the course but can be accessed on the website. The main contact is Mary Culber, at Mary.Culber@noaa.gov
To request in-person trainings, send an e-mail to csc.training.request@noaa.gov.
Users can fill out a question form at: http://www.csc.noaa.gov/contact/contactForm.htm
Keywords: Training; Workshops; Coastal management
Cost: Varies
Training/Time Requirements: Varies
Other Requirements/Notes: None

- **Ecosystem Based Management (EBM) Tools**
  http://www.ebmtools.org/about_ebm_tools.html
  This website offers a wide variety of tools and toolkits. Users can search the database for a tool that fits specific requirements. Tool categories include: Decision Support Tools; Modeling and Analysis Tools; Data Collection, Processing; Management Tools; Stakeholder Engagement and Outreach Tools; Conceptual Modeling Tools; Visualization Tools; Project Management Tools; Monitoring and Assessment Tools. This website also offers a wide range of training opportunities.
  Contact: Sarah Carr, ebmtools@natureserve.org
  Keywords: Ecosystems; Tool acquisition
  Cost: No cost to search website
  Training/Time Requirements: None (time to search website/learn about tools)
  Other Requirements/Notes: None

- **Great Lakes Weather and Climate**
  http://www.ssec.wisc.edu/sose/glwx_activity.html
  This website displays remote sensing images in order to explain Great Lakes weather and climate patterns. Module 'A' examines the reasons behind weather and climate patterns of the Great Lakes. Module 'B' examines patterns associated with spring and autumn while Module 'C' examines patterns associated with summer and winter.
  Contact: Richard Wagenmaker Richerd.Wagenmaker@NOAA.gov
  Keywords: Remote sensing; Education; Modules
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **Ohio Sea Grant Webinars**
  http://www.ohioseagrant.osu.edu/
  Ohio Sea Grant and Ohio State University offer educational webinars about once a month that cover climate change related topics in the Great Lakes Area. These modules can help participants learn more about how climate change may impact the Great Lakes area with respect to special topics or in more of a broad scope.
  Contact: Jill Jentes-Banicki jents.1@osu.edu

Please visit the Ohio Sea Grant contact webpage: http://www.ohioseagrant.osu.edu/contact/ to find a contact that fits your needs. Otherwise, you can choose to “leave a note” and the office will help answer your question or direct you to a particular person.
Keywords: Education; Great Lakes
Cost: Free for most
Training/Time Requirements: The time it takes to attend the webinar
Other Requirements/Notes: Most webinars are free, but pre-registration is required

- **Planning for Climate Change Workshop**
  http://www.nerrs.noaa.gov/Training.aspx
  The National Estuarine Research Reserve Training System will offer a Coastal Training Program specially made for Great Lakes coastal decision makers. The training will provide decision makers with the skills to plan for climate change issues in their communities. Information in the training will be customized for the Great Lakes region. Training will be available at a number of different locations, and will be coordinated through Old Woman Creek Reserve in Ohio.
  Contact: Heather Elmer Heather.Elmer@dnr.state.oh.us
  Keywords: Coastal management; Education
  Cost: Varies depending on location
  Training/Time Requirements: Not Yet Determined
  Other Requirements/Notes: Training will be available spring 2011

Data Websites

The following resources are places that users can locate data to use in conjunction with other tools or for decision making. Most websites are fairly easy to use and offer downloadable data formats or allow users the option to save or print the data they find. Searchable data varies from shapefiles for ArcGIS to demographic data on specific areas, to historical maps and charts. These resources can be used to find data for adaptation planning tools, or to find local data, which is crucial for climate change adaptation planning. Data websites would be most useful in the middle of an adaptation process, likely before and while decision makers are choosing strategies for adaptation.

- **Coastal Change Analysis Program Regional Land Cover**
  http://www.csc.noaa.gov/landcover
  This tool offers land cover data sets for coastal areas that can be downloaded for free. The Coastal Change Analysis Program updates data layers every five years, helping to monitor changes in coastal habitats. Remotely sensed data is used to make the layers, with multiple dates so that users can see changes over time. Data is available for download and is in a raster format.
  Contact: The main contact is Nate Herold Nate.Herold@noaa.gov
  For support see:
  http://www.csc.noaa.gov/digitalcoast/data/ccapregional/support.html
  Questions can be directed to: nos.csc.ccap@noaa.gov
  Keywords: Land use; Land cover; Remote sensing
  Cost: None
  Training/Time Requirements: Experience working with raster data sets; No training offered through the website

Other Requirements/Notes: None

- **Coastal County Snapshots**
  http://www.csc.noaa.gov/digitalcoast/tools/snapshots
  The Coastal County Snapshots tool provides users with a quick look at a county's demographics, infrastructure, and environment within the flood zone. A map and pull-down menus let users pick their state and county of interest (data is not available for every US county), and a report is provided for download that can be saved or printed.
  Contact: Tashya Allen, Tashya.Allen@noaa.gov
  Users can fill out a question form at:
  http://www.csc.noaa.gov/digitalcoast/feedback.html
  Keywords: Flood hazard; County-specific data
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **Great Lakes Information Network (GLIN) Maps and GIS**
  http://www.gis.glin.net/
  This GLIN webpage offers users a number of different GIS data layers specific to the Great Lakes region. The data is downloadable in a shapefile format, and can be found by searching by topic, organization, geography, or upload date. Topics include: Biota; Boundaries/Political; Climatology/meterology/atmosphere; Elevation; Environment; Geoscientific Information; Health; Imagery/basemaps/earth_cover; Inland Waters/Hydrography; Society; Structures/Facilities; and Transportation.
  Contact: Pete Giencke, pgiencke@glc.org
  Keywords: ArcGIS; Shapefiles
  Cost: None
  Training/Time Requirements: GIS skills necessary to utilize data
  Other Requirements/Notes: None

- **Historical Maps and Charts**
  http://www.nauticalcharts.noaa.gov/csdl/ctp/abstract.htm
  Users can access this free map and chart collection, which contains thousands of maps and charts from 18th century to modern day. Featured maps include nautical charts, hydrographic surveys, topographic surveys, etc.
  Contact: Brian.Link@noaa.gov
  Or you can search for a contact to address your specific question or need at:
  http://www.nauticalcharts.noaa.gov/staff/contact.htm
  Keywords: Mapping; Historical data
  Cost: None
  Training/Time Requirements: Basic chart and map comprehension
  Other Requirements/Notes: None

- **MyEnvironment**
  http://epa.gov/myenvironment
  Users can enter in their zip code and receive health, air, ozone and other information specific to counties. They also have access to features like hazardous waste facilities mapping or cancer risks pie charts associated with

their geographical location.
Contact: None listed for MyEnvironment tool
Keywords: Health; Hazards
Cost: None
Training/Time Requirements: None
Other Requirements/Notes: None

- **New York Ocean and Great Lakes Atlas**
  http://nyoglatlas.org/
  This link leads users to the New York Ocean and Great Lakes Atlas: Data Viewer, where users can view various data layers on New York and the Great Lakes in the area. Layer boundaries include, but are not limited to: administrative, New York State boundaries, watersheds, populations, estuaries, sewage treatment plants, and historic sites. This site is free to use and is meant to be accessed by the general public but would also be useful for government organizations, public companies, or universities.
  Contact: Jeff Herter, jeff.herter@dos.state.ny.us
  Keywords: Data viewer; Coastal management
  Cost: Free
  Training/Time Requirements: None
  Other Requirements/Notes: If users need help using the data viewer, they can click on the question mark and be redirected to the help section.

- **NOAA Digital Coast**
  http://www.csc.noaa.gov/digitalcoast/
  The NOAA Digital Coast Website offers data to assist communities with coastal management issues, and provides the tools, training, and information needed to turn these data into information that is used to address timely coastal issues, including land use, conservation, hazards, marine spatial planning, and climate change. Stories are shared from around the United States, showing how the data and tools have been used successfully to manage the coasts. The website offers resources that are related to coastal management, but not all climate change related.
  Contact: Kirk Waters Kirk.Waters@noaa.gov
  You can also contact NOAA Digital Coast by filling out a question form at: http://www.csc.noaa.gov/digitalcoast/feedback.html
  Keywords: Tool acquisition; Coastal management
  Cost: None (time to search website)
  Training/Time Requirements: None (time to search website/learn about tools)
  Other Requirements/Notes: None

- **NOS Data Explorer**
  http://nosdataexplorer.noaa.gov/nosdataexplorer
  This tool is a collection of spatial information related to coastal areas and oceans, including “bathymetry, coastal maps, environmental sensitivity index maps, aerial photographs, etc.” Users can download data from the site and utilize their interactive mapping tools.
  Contact: For questions, please email nosdataexplorer.noaa.gov
  Keywords: Coastal data; Database
  Cost: None

Training/Time Requirements: None
Other Requirements/Notes: None

- **Ohio Coastal Atlas**
  http://www.ohiodnr.com/AtlasGIS/tabid/19562/Default.aspx
  The Ohio Coastal Atlas is a collection of resources and maps on Lake Erie and its watershed. Resources include: a digital, interactive coastal atlas; maps; GIS data; and contacts. Users can also examine a wind turbine placement viewer, a ports and harbors map, a watersheds map, and coastal erosion areas.
  Contact: Brian George, brian.george@dnr.state.oh.us
  Keywords: Data; Ohio; Lake Erie
  Cost: Free
  Training/Time Requirements: None, except may need to utilize help functions to use some of the interactive maps.
  Other Requirements/Notes: None

- **Wisconsin Coastal Atlas**
  http://wicoastalatlas.net/
  This atlas provides access to maps, and other related data on Wisconsin and the Great Lakes. There are links that direct users to mapping sites like the Wisconsin County and Municipal Web Mapping Site, and maps like the Coastal Heritage Tourism Map. There are also links to spatial data layers and websites, and spatial decision tools.
  Contact: David Hart, dhart@aqua.wisc.edu
  Keywords: Wisconsin; Maps; Data
  Cost: Free
  Training/Time Requirements: None, except to utilize and download GIS data
  Other Requirements/Notes: None

Analysis Tools and Systems

The following analysis tools and systems are processes and/or software that require a moderate time investment from users in order to understand and operate the systems/tools or to carry out the method described in the system/tool. The analysis tools vary from hazard assessment systems to ecosystem restoration methods to water quality analysis tools/systems. Some require extensive computer knowledge while others are fairly user friendly. Analysis tools and systems can be used at different stages of the planning process—early on to identify hazards, or later on when decision makers are strategizing for adaptation.

- **Better Assessment Science integrating point and Non- Point Sources 4.0 (BASINS 4.0)**
  http://www.epa.gov/waterscience/basins/
  BASINS allows users to explore possible effects of climate change on watersheds and water quality. This tool combines national watershed data, GIS, modeling tools, and assessment tools into an open-source GIS system. BASINS can be utilized for a number of different purposes and can be used by local, state, and regional organizations.
  Contact: None listed; website provides a link where users can send questions to the EPA Office of Water
  Keywords: Water quality; Watersheds; Modeling

Cost: None
Training/Time Requirements: 4 ½ hour day training session
Other Requirements/Notes: A basic understanding of watershed hydrology and water quality processes needed. Powerpoint lectures and exercises available on EPA website.

- **CITYgreen**
  https://www.amfor.org/productsandpubs/citygreen/
  CITYgreen analyzes ecological and economic benefits of tree canopy and other green space. Stormwater runoff, air pollution removal, carbon storage and sequestration and, landcover breakdown are all analyzed by the software. Communities can use the alternate scenario modeling feature for decision-making and planning purposes.
  Contact: info@amfor.org
  Keywords: Green infrastructure; Planning and policy
  Cost: Price varies. ($895 for commercial and government agencies)
  Training/Time Requirements: GIS proficiency
  Other Requirements/Notes: Hardware requirements: Platform PC-Intel Processor 1.0 GHz or higher, 480MB of free disk space, 1 GB memory recommended.
  Software requirements: Windows 200 or XP, ArcGIS 8 or 9 and Spatial Analyst extension
  A landcover dataset is needed for analysis and must be classified (open space, impervious surfaces, water, etc.) prior to analysis..

- **FEMA HAZUS**
  http://www.fema.gov/plan/prevent/hazus/index.shtm
  FEMA offers free HAZUS software to federal, state, and local governments to assist in risk assessment and planning for mitigation efforts. FEMA HAZUS is meant to help prevent losses associated with disasters such as earthquakes, hurricanes, and flooding.
  Contact: Program contacts:
  Eric Berman, HAZUS Program Manager and HAZUS Training and Education, Eric.Berman@dhs.govTelephone: (202) 646-3427
  Vince Brown, HAZUS User Groups (HUGs), Private Sector, E-mail: Vincent.Brown@dhs.gov Telephone: (202) 646-2725
  Phillip Moore, Emergency Management Institute and Training, Email: Phillip.Moore@dhs.gov Telephone: (301) 447-1248
  Keywords: Hazard assessment; Vulnerability assessment; Flood hazard; Disaster management; ArcGIS
  Cost: None (for HAZUS-MH 4 Version)
  Training/Time Requirements: Three day training for basic course. Additional training sessions are available for varying topics.
  Other Requirements/Notes: Hardware requirements: Pentium III 1GHz; Supporting software: ArcView 9.3 or ArcGIS 9.3.1. ArcGIS Spatial Analyst extension required for flood model. Certification is available for professional and advanced users.

- **Habitat Priority Planner**
  http://www.csc.noaa.gov/digitalcoast/tools/hpp

Habitat Priority Planner is an ArcGIS toolbar that helps users make decisions related to “habitat conservation, restoration, and land use planning.” Users can examine various hypothetical situations through maps and reports that allow communities to make informed decisions and to more efficiently communicate possibilities.
Contact: Bethney Ward, Bethney.Ward@noaa.gov
Or you can also contact nos.csc.hpp@noaa.gov
Keywords: Environmental analysis; Ecosystem restoration; Land use planning; Stakeholder engagement; Conservation
Cost: None
Training/Time Requirements: A one-day, instructor-led course is offered. Participants should have intermediate GIS experience
Other Requirements/Notes: Microsoft .NET and Microsoft .NET Support for ArcGIS, ArcMap 9.2 or 9.3, Spatial Analyst. Raster or vector land cover data and other data layers required.

- **Impervious Surface Analysis Tool**
  http://www.csc.noaa.gov/isat
  This tool allows users to examine the percent of impervious surfaces in various areas, which can then be used to analyze possible water quality impacts of different management methods. This tool is meant to be an extension of ArcGIS and therefore requires that the tool be used in conjunction with ArcGIS software.
  Contacts: Dave Eslinger, Dave.Eslinger@noaa.gov
  Or Users can find a question form at:
  http://www.csc.noaa.gov/digitalcoast/feedback.html
  Keywords: Impervious surfaces; Water quality; ArcGIS
  Cost: None
  Training/Time Requirements: Varies. ArcGIS skills required
  Other Requirements/Notes: Technical specifications: Arc 9.x, Spatial Analyst, raster-based land cover data or land use grid, polygon data set and set of impervious surface coefficients.

- **i- Tree v3.0**
  http://www.itreetools.org/index.php
  I-Tree is a free software based tool that helps users quantify the benefits of trees and forests in their communities. The tool is applicable at multiple scales, ranging from a single tree to an individual forest to an entire state. Results generated from this tool can be used to help shape forest and tree management plans, involve and engage different stakeholders, among other applications. The i-tree v3.0 suite contains 5 parts: i-Tree Eco, i-Tree Species, i-Tree Streets, i-Tree Storm, i-Tree Vue.
  Contact: info@itreetools.org (i-Tree related questions)
  Or you can reach the i-Tree forum at: http://forums.itreetools.org/index.php
  Phone Number: 877-574-8733
  Keywords: Urban greenspace; Forest management
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: A User Forum is available for users to troubleshoot; There is also an i-Tree Bug Reporting and Tracking features on the website; Customer service is available Monday through Friday via phone

- **NatureServe Vista**
http://www.natureserve.org/prodServices/vista/overview.jsp
NatureServe Vista is an analysis system that can help decision makes and planners make land use and planning decisions while keeping a conservation framework in mind. The software can be assist users with carrying out conservation assessments and planning projects, to help planners incorporate conservation principles in land use planning, and evaluate current and potential land use strategies. NatureServe works to incorporate a number of different, important components including “science, expert opinion, community values, and GIS.” The site offers a number of support avenues for users, from user forums to sample datasets to online technical support.
Contact: Users can visit the following website: http://www.natureserve.org/contactUs/index.jsp to find key contacts or search the NatureServe Network Staff Directory to find staff members who specialize in specific areas
Contact: vista@natureserve.org
Visit the following website to find a contact that fits your needs: http://www.natureserve.org/contactUs/index.jsp
Keywords: Conservation; ArcGIS
Cost: Free
Training/Time Requirements: ArcGIS skills required; Website offers range of different training modules ranging from $150 to $200, that last from 1.5 hours to 2.5 hours.
Other Requirements/Notes: ArcGIS required

- **Nonpoint Source Pollution and Erosion Comparison Tool (N- SPECT)**
http://www.csc.noaa.gov/nspect
N-SPECT is a tool that can be used to determine what effects land use changes, especially development, may have on hydrologic systems. It can also be used to examine effects on hydrologic systems from climate change. While N-SPECT can be used for various sized watersheds, it was created to mostly to examine medium and large sized watershed, but can apply to any.
Contacts: David Eshlinger, David.Eslinger@noaa.gov
For support, go to:
http://www.csc.noaa.gov/digitalcoast/tools/nspect/support.html
Users can ask a question at:
http://www.csc.noaa.gov/digitalcoast/feedback.html
Keywords: Pollution; Watershed management
Cost: Free
Training/Time Requirements: 3 hour training
Other Requirements/Notes: Requires ESRI Arc 9.X, ESRI Spatial Analyst; Also has specific data requirements; ArcGIS experience required; Tutorial and user’s manual available on website

- **Roadmap for Adapting to Coastal Risk**
http://www.csc.noaa.gov/coastal
This website offers a systematic approach that assists users in breaking down coastal ecosystem conservation projects into strategic and manageable steps. The approach (and website) is organized around five main components:

Planning, Implementation, Performance Assessment, Adaptive Management, and Dissemination of Results. The website also provides background information on ecosystem conservation including why restoration is important and the kinds of challenges these kinds of projects may face.
Contact: csc.info@noaa.gov
Keywords: Coastal ecosystems; Restoration
Cost: None
Training/Time Requirements: Varies—No training required
Other Requirements/Notes: None

Other Informational Websites

The following tools direct users to additional information on climate-related topics. Time investment is up to the user, as they decide which features to interact with or which additional tools to examine. These tools do not necessarily fit into a specific part of the climate change adaptation planning process, but can be used as supplemental information throughout the process.

- **Lake Superior Duluth Streams.org**
  http://www.lakesuperiorstreams.org/
  This website offers information about streams, hydrology, and water management to interested parties in Minnesota and Wisconsin. Users can find information on hydrology, including stormwater and best management practices. Most information, such as permitting requirements and data on rivers, is specific to Minnesota and Wisconsin only; however there is also valuable information for other Great Lakes residents on concepts such as inflow and infiltration, and some general management practices.
  Contact: Cynthia Hagley, chagley@umn.edu
  Jesse Schomberg, jschombe@d.umn.edu
  Users can also submit questions and comments at the following link:
  http://www.lakesuperiorstreams.org/general/contactus.html
  Keywords: Watershed management; Stormwater Management; Minnesota; Wisconsin
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **NatureServe (Website)**
  http://www.natureserve.org/index.jsp
  The NatureServe website offers tools and data to assist users incorporate conservation into land use and natural resource planning. Users can browse current NatureServe projects, find local programs, find species and ecosystem related data, and learn about other NatureServe resources. Under the "Products & Services" heading, users can download other NatureServe tools and learn about other services NatureServe can provide.
  Contact: Users can search the contact lists at the following link:
  http://www.natureserve.org/contactUs/index.jsp
  Keywords: Conservation; Software; Landuse planning
  Cost: None (to browse website)
  Training/Time Requirements: None(to browse website)
  Other Requirements/Notes: None

- **NOAA Coastal Climate Adaptation**
  http://collaborate.csc.noaa.gov/climateadaptation/
  The NOAA Coastal Climate Adaptation website offers information and resources on climate change for coastal communities. Easy-to-understand climate change science information is provided, as well as examples of the various strategies communities are employing and plans and policies that have been developed to address climate change impacts. Resources can also be located using the clickable state map. Users can upload resources for their state and engage in discussions about climate-related solutions. Another feature of the website, called "Getting Started" helps communities get started on climate change adaptation.
  Contact: Stephanie Fauver, Stephanie.Fauver@noaa.gov
  nos.csc.cca@noaa.gov
  Keywords: Coastal management; NOAA; Adaptation; Climate change
  Cost: None (time to search website)
  Training/Time Requirements: None (time to search website/learn about tools)
  Other Requirements/Notes: None

- **NOAA Climate Services Portal**
  http://www.climate.gov
  This website offers climate information ranging from data and services to educational materials and information. The website allows users to browse ClimateWatch articles, and offers information to educate users on climate principles. Data is available on past climatic conditions and predictions. Users can also learn how to best use climate data in their own projects.
  Contacts: The following website offers users information on frequently asked questions and contacts: http://www.climate.gov/faq.html
  Keywords: Climate education; Data
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **NOAA State of the Coast**
  http://stateofthecoast.noaa.gov/
  This website offers information about the importance of healthy coasts, and emphasizes the interconnectedness between the economy, communities, climate, and ecosystems. Users can learn about the demographics of people living in coastal areas, details of coastal economies and ecosystems, and how climate can impact all three.
  Contacts: stateofthecoast@noaa.gov
  Get URL here
  Keywords: Coastal climate; Coastal ecosystems
  Cost: None (to browse website)
  Training/Time Requirements: None (to browse website)
  Other Requirements/Notes: None

Visualization Tools

The Visualization tools listed below help users envision effects of climate change and/or coastal development. These tools can be useful for climate change adaptation planning because they can help to visualize the effects of climate change or how adaptation measures may alter the environment. The time investment can vary by tool, as CanVis requires a fair amount of time investment for users to become familiar with the interface. However, the Visualizing Coastal Erosion and Climate Wizard websites are interactive website that do not require training and have a minimal time investment, which is dependent on the extent of reading and interacting with features on the website.

- **CanVis**
  http://www.csc.noaa.gov/canvis
  This tool assists users in visualizing potential impacts of coastal development and climate change. Users can add pictures of buildings or structures to see what visual impacts these developments may have on a larger scale. Users can play with various scenarios, such as increasing or decreasing sea levels, in order to visualize potential climate change impacts. CanVIS is not a modeling system, and therefore users may need to base simulations on data from other models and predictions. This tool does not require extensive computer familiarity and users can upload their own photos. Users can also find images from the following website:
  http://www.csc.noaa.gov/digitalcoast/tools/canvis/download.html
  Contact: Email Hansje Gold-Krueck, Hansje.Gold-Krueck@noaa.gov
  nos.csc.canvis@noaa.gov
  Keywords: Coastal development; Impact visualization
  Cost: None
  Training/Time Requirements: 3 hour virtual training seminar, Internet and phone required; WebEx software and user instructions are provided
  Other Requirements/Notes: Free technical assistance is also available

- **Climate Wizard**
  www.climatewizard.org/index.html
  This tool illustrates various IPCC climate change scenarios in the US. Users can view averages and changes in temperature and precipitation in the past 50 years and projections into the future. Resources are also available that illustrate case studies and documentation.
  Contact: Contact list on website: http://www.climatewizard.org/ContactUs.html
  Keywords: Climate change impacts; IPCC predictions
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: Public access via webpage

- **Visualizing Coastal Erosion**
  http://www.geography.wisc.edu/coastal/
  Visualizing Coastal Erosion is an interactive website that allows users to see the effects of coastal erosion in Ozaukee County, Wisconsin. Users have access to interactive exhibits that illustrate how erosion happens and depicts the change in landscape over the last 40 years, among over features.
  Contact: David Hart, dhart@aqua.wisc.edu
  Or see website for list of contacts, listed with their involvement with the project
  Keywords: Erosion; Coastal development
  Cost: None

Training/Time Requirements: No additional training required
Other Requirements/Notes: None

State and Regional Climatologist Contacts

Climatologists are local experts on the climate. Each state and region has their own State and Regional Climatology Centers, where climatologists have many climate related responsibilities. In their duties as climatologists, their responsibilities include: Collecting and analyzing climate related data; Communicating climate information to local communities; Helping these communities understand the importance of utilizing climate data to make decisions; Undertaking climate impact assessments; Researching climate issues and use this information to make projections. Depending on time and resources, many climatologists can also be a valuable contact in the adaptation planning process. Below is a list of regional and state climatologists and their climatology offices for Great Lakes coastal states.

- **Midwestern Region**
  Midwestern Regional Climate Center
  Contact: Steve Hilberg, hberg@illinois.edu
  Website: http://mrcc.isws.illinois.edu/

  - **Michigan**
    Michigan State Climatology Office
    Contact: Jeffrey Andreson, andresen@msu.edu
    Website: http://climate.geo.msu.edu/

  - **Ohio**
    Ohio State Climatology Office
    Contact: Jeffery Rodgers, rogers.21@osu.edu
    Website: http://www.geography.ohio-state.edu/faculty/rogers/statclim.html

  - **Indiana**
    Indiana State Climatology Office
    Contact: Dr. Dev Niyogi, dniyogi@purdue.edu
    Website: http://iclimate.org/

  - **Illinois**
    Illinois State Climatology Office
    Contact: Dr. Jim Angel, jimangel@uiuc.edu
    Website: http://www.isws.illinois.edu/atmos/statecli/index.htm

  - **Wisconsin**
    Wisconsin State Climatology Office
    Contact: John Young, STCLIM@aos.wisc.edu
    Website: http://www.aos.wisc.edu/~sco/

- **Northeast Region**

Northeast Regional Climate Center
Contact: Arthur DeGaetano, atd2@cornell.edu
Website*:* http://www.nrcc.cornell.edu/

- **Pennsylvania**
  Pennsylvania State Climatology Office
  Contact: Paul Knight, knight@mail.meteo.psu.edu
  Website: http://climate.met.psu.edu/www_prod/

- **New York**
  New York State Climatology Office
  Contact: Mark Wysocki, nysc@cornell.edu
  Website: http://nysc.eas.cornell.edu/

Climate Ready Great Lakes Module 3:
How do I choose the right tool?

1. Define the Goal/objective that you are trying to achieve. Below write an adaptation goal that is relevant to your specific locality. How does this relate to other adaptation efforts in your city?

   Goal:

   Relation to other adaptation efforts:

2. Review the climate impacts spreadsheet. Write down the tools that can assist with the climate impact that you are trying to mitigate. List the category next to each tool. Later, you will be able to determine the appropriate use for the tools that you selected.

Climate Impact	Tool Name

3. What other resources do I need to use this tool? Trained staff? Data? How do I get the resources that I need?

Tool Name	Staff Requirements	Technical Requirements	Other Requirements

Module 3 Handout User Guide

Two main documents were created to help community planners select tools that are appropriate for their needs.

1. Great Lakes Tool Application Spreadsheet
2. Great Lakes Adaptation Handout

Step One: Refer to the Great Lakes Tool Application Spreadsheet

The Tool Application Spreadsheet is a one-shot glance of the tools selected by Module 3 reviewers as appropriate for Great Lakes climate change adaptation planning. These tools were put into various categories (community outreach, data, etc.) to help users understand where the tool fits into various steps of the planning process.

The tools are listed according to category. Across the top of the spreadsheet are possible climate change adaptation issues or impacts (chosen based on Module 2). An 'X' is placed in each box where the reviewers found usefulness of the tool in helping with the particular climate change impact.

Step Two: Select tools and Refer to the Great Lakes Adaptation Handout

The user can select tools from one or multiple categories based on project needs. Once a tool is identified as a possible candidate for use, the Great Lakes Adaptation Handout is a resource for learning more about the tool and includes information on cost, training and time requirements as well as places to locate more information.

After researching the tool, it may be necessary to return to the spreadsheet and find a different tool that may be more suitable for a particular project. This process was intended to help users find the tools they need in the most efficient manner. In the case where users are unable to find an appropriate tool, a listing of state climatologists is located at the end of the handout. These individuals are a valuable resource to find more information on the latest and upcoming tools.