CLIMATE READY GREAT LAKES: SUPPORT NOTEBOOK
TABLE OF CONTENTS

INTRODUCTION

Climate Ready Great Lakes is a three-module set of presenations tailored towards helping to create a Great Lakes region that is "climate ready." The purpose of these modules is to provide stakeholders and decision makers with clear information about Great Lakes climate, what they should be ready to adapt to, why and how. This project was sponsored by the Great Lakes Sea Grant Network and the NOAA Great Lakes Regional Collaboration Team.

Each module consists of a presentation (available in PowerPoint format) and supplemental materials, such as worksheets, handouts, and evaluation forms that presenters may wish to use at the end of a presentation or training workshop. All of the supplemental materials are presented here in this Support Notebook. The modules may be presented in their entirety, or users may wish to select a subset of the slides and support materials from one or more modules to suit their particular needs.

The full Climate Ready Great Lakes modules (in PowerPoint format) and this Support Notebook are available for free download via the NOAA website:
http://www.regions.noaa.gov/great-lakes/?page_id=24

For questions regarding the Climate Ready Great Lakes modules or the project, please contact Rochelle Sturtevant (rochelle.sturtevant@noaa.gov).

CLIMATE READY GREAT LAKES:
MODULE 1 – WHAT AM I ADAPTING TO?

UNDERSTANDING THE IMPACTS OF CLIMATE CHANGE IN THE GREAT LAKES

SCOPE

This module will present an overview of predicted climate change impacts in the Great Lakes, including predicted changes in temperature, storm events, Great Lakes water levels, lake ice cover, and other factors. The module is designed to assist local decision makers in understanding the potential range of variability in climate change predictions and how these changes are likely to impact local communities.

GOALS

1. Participants will be familiar with predicted climate impacts for the Great Lakes region.
2. Participants will understand why they should include climate change adaptation in their planning processes.

OBJECTIVES

By the end of the training…

1. Participants will understand that climate change has scientific basis and is a relevant issue for planning professionals and others from a variety of sectors.
2. Participants will understand that there will be similarities and differences between climate change impacts observed at the regional (Great Lakes) and global scales.
3. Participants will be able to identify at least one climate change impact specific to the Great Lakes region that will affect issues within their own professions.

MODULE 1: OUTLINE

Part I: Fundamentals of Climate Change

1. Climate Science: Weather and Climate
2. Observed and Projected Global Change
3. Climate Change in the Great Lakes Region

Part II: Implications for Great Lakes Communities

1. Lake Levels
2. Ice Cover
3. Severe Weather
4. Ecosystem Changes
5. Human Health & Economy

Workshop Evaluation: Climate Ready Great Lakes

Module 1: What Am I Adapting To?

Directions: Please read carefully and respond to the following questions:

1) Has this presentation improved your understanding of the scientific basis for climate change? (Check one.)

☐ Greatly improved	☐ Somewhat improved	☐ Slightly improved	☐ No change

2) Has this presentation improved your understanding of how global climate change impacts the Great Lakes local climate and weather?

☐ Greatly improved	☐ Somewhat improved	☐ Slightly improved	☐ No change

3) After this presentation, I can now identify ____ (# of) climate change impacts specific to the Great Lakes that will affect issues within my profession.

☐ 0-1	☐ 2-3	☐ 4-5	☐ More than 5

4) If possible, list three climate change impacts specific to the Great Lakes region that are specific to your planning needs:

a.

b.

c.

5) How likely are you to incorporate information on climate change into your future planning activities?

☐ Very likely	☐ Somewhat likely	☐ Slightly likely	☐ Not at all likely

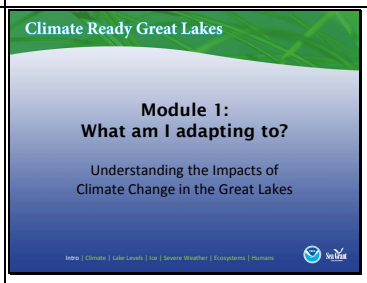
6) How likely are you to seek additional information on local climate impacts as you engage in future planning activities?

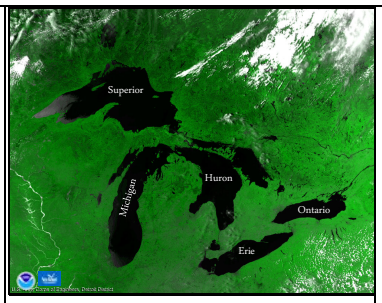
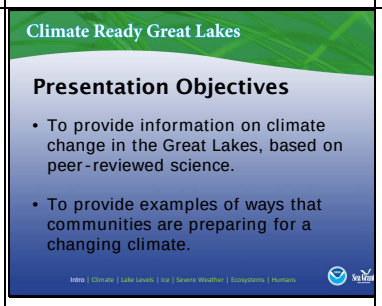
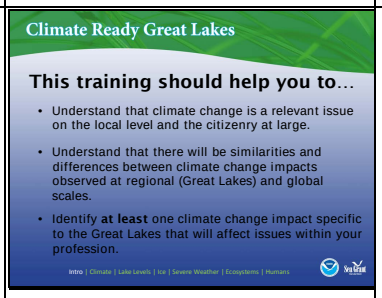
☐ Very likely	☐ Somewhat likely	☐ Slightly likely	☐ Not at all likely

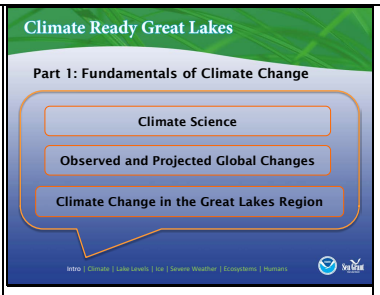
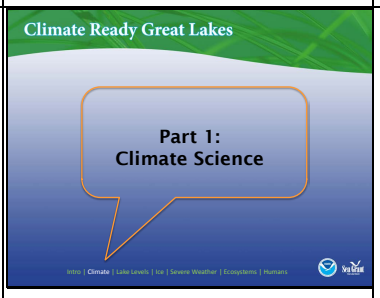
7) Additional comments…

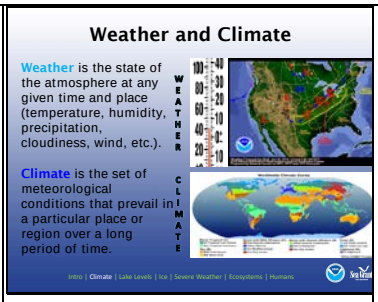
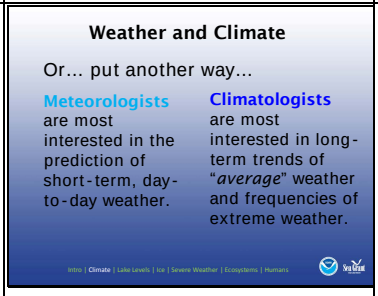
(This Page Intentionally Left Blank)

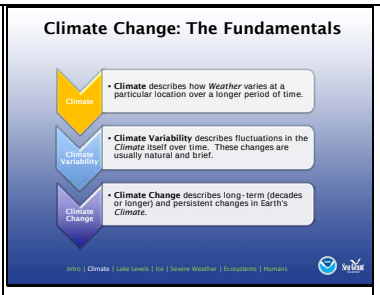
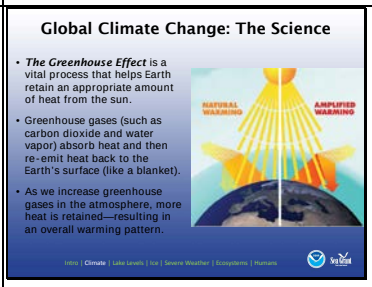
MODULE 1: SLIDES AND NOTES

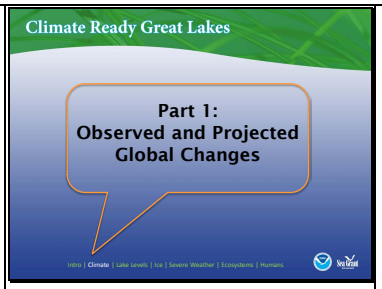
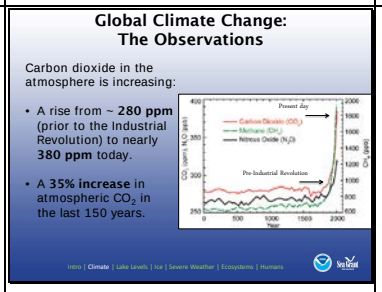
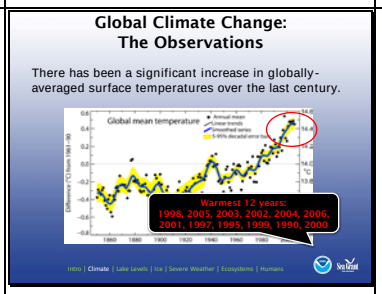
Slide 1		Welcome to this training on "Climate Ready Great Lakes!" This presentation features content that was developed on behalf of the NOAA Great Lakes Regional Collaboration Team and the Great Lakes Sea Grant Network.
Slide 2		This is the first of three modules developed to help people and communities in the Great Lakes region become more "climate ready." This module provides insights into the question, "What am I adapting to?" – specifically, providing a general introduction to climate science and the trends and impacts of climate change specific to the Great Lakes region.
Slide 3		*(Dr. Jane Lubchenco has been the under secretary of commerce for oceans and atmosphere and administrator of NOAA, the National Oceanic and Atmospheric Administration, since 2009.)* 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

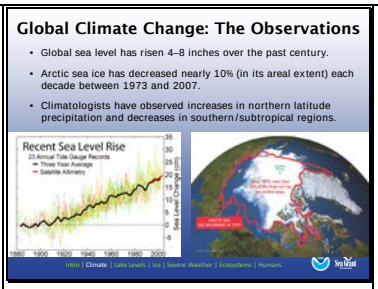
Slide 4		However, much of what we hear or read is about <u>global</u> climate change. This presentation is different. While we will discuss global climate change in the beginning of our presentation, the purpose of this training is to discuss how climate change may affect <u>the Great Lakes region</u>.
Slide 5		With that in mind, the goals of this training are to: 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 adhere to the professional standards of peer-reviewed research. An annotated bibliography of these articles provides the basis for this training; we will pass out the bibliography handout after the presentation. **[CLICK]** The second goal is to provide you with examples of ways that communities are preparing for a changing climate.
Slide 6		By the end of this training you should be able to… **[READ BULLETS]**

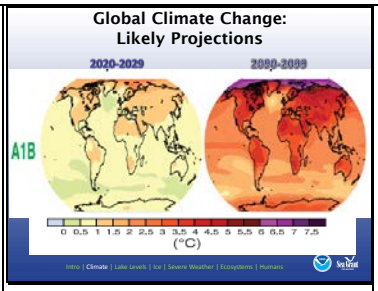
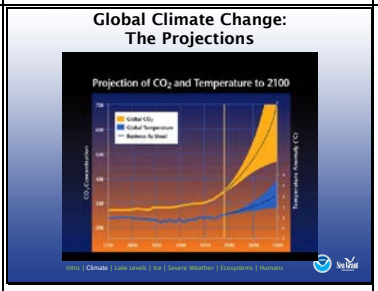
Slide 7		Today's presentation is broken up into six interrelated sections, which are listed in the toolbar at the bottom of the slide. Part 1 of the presentation is divided into three sub-sections, which are designed to help you understand the fundamentals of climate change. First, we'll discuss the differences between **Weather** and **Climate**, and then we'll discuss some basics about climate science 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, as well as those **changes that are projected to occur.** Finally, we'll discuss the Great Lakes climate and projected changes for the region.
Slide 8		In part 2 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, and human health and the economy.
Slide 9		

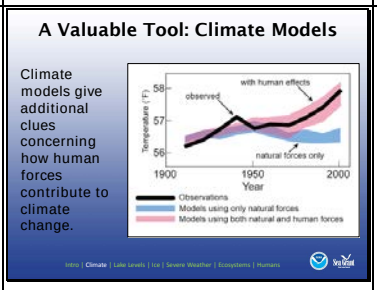
Slide 10		**Before we begin discussing how climate change might impact the Great Lakes region, let's first review the key differences between weather and climate.** An accurate understanding of the difference between weather and climate is critical to understanding the concept of climate change. **Weather** 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 that "In general, it's cold and snowy." This is climate.** Image citations: Columbia Service Learning Program (CSLP). http://community.seas.columbia.edu/cslp/ Hydrometeorological Prediction Center (HPC). http://www.hpc.ncep.noaa.gov/noaa/noaa.gif COMET Program Module: "Introduction to Climatology." http://www.meted.ucar.edu/afwa/climo/intro/print.htm
Slide 11		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.

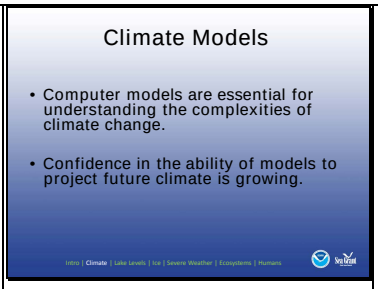
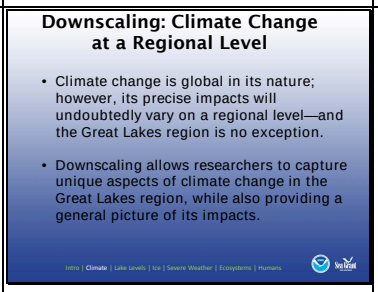
Slide 12		**So to summarize…** **[CLICK]** Climate describes how *Weather* varies at a particular location over a longer period of time. In other words, it's the average of all the weather spread over a long period of time. *Normals* are derived from averaging the weather. **[CLICK]** Climate variability describes changes in the *Climate* itself over time. Such changes are usually natural and of a brief timescale. **[CLICK]** Climate Change describes longer-term (decades or longer) and persistent changes in Earth's *Climate*. This may be described as persistent or permanent changes in the Normals.
Slide 13		**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 Effect is a vital and healthy planetary process that helps the Earth retain heat from solar radiation. However, increased amounts of greenhouse gases emitted into the atmosphere mean that 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 citation: http://www.nps.gov/grba/naturescience/what-is-climate-change.htm

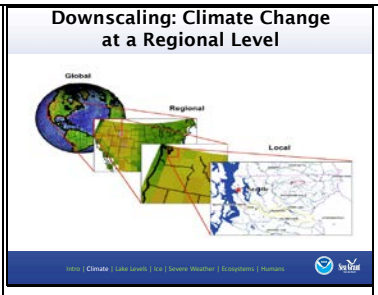
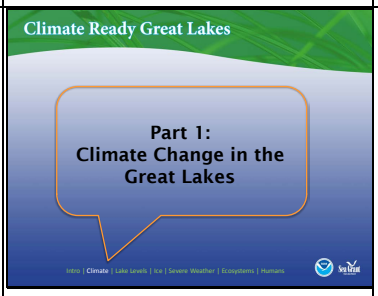
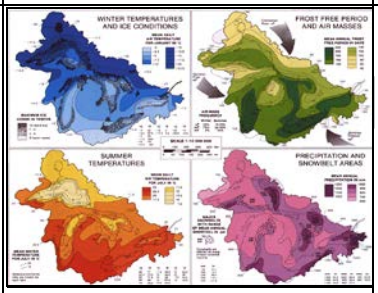
Slide 14		
Slide 15		**So how do we know that human activity is amplifying the Earth's greenhouse effect?** Carbon dioxide in the atmosphere is increasing: We have observed a rise from approximately **280** ppm (prior to the Industrial Revolution) to nearly **380** ppm today. That's a **35% increase** in CO2 emissions over the last 150 years. Source citation: Intergovernmental Panel on Climate Change (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.
Slide 16		Coincident to these observed increases in atmospheric CO2, we have observed an increase in global average surface temperatures. The Earth has warmed approximately 1° Celsius (or 1.8° Fahrenheit) since the beginning of the Industrial Revolution. In the last 150 years, the warmest 12 years have been observed from 1990–2006. Source citation: Intergovernmental Panel on Climate Change, 4th Assessment Report

Slide 17		**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 4–8 inches (10–20 centimeters) 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 (that is, the changes that have already occurred). **Key Points:** This slide is fairly self-explanatory: it is a list of consequences that our planet has already experienced as a result of global climate change. Different from forecast or projected changes, this list of changes is already a reality—so, it is not necessary to emphasize uncertainty here. **Figures:** There are 2 figures in play here. The next figure depicts recent rises in sea level; the colored area depicts various measurements and a black/red line represents a consensus. Finally, the last figure depicts recent reductions in Arctic sea ice coverage, which is self-explanatory. Image citations: Recent Sea Level Rise image: http://astro.wsu.edu/worthey/astro/html/lec-climate.html Arctic Sea Ice image: http://www.nrdc.org/globalwarming/images/

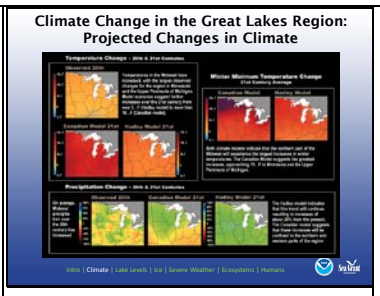
Slide 18		**So, what do** scientists think might result from continued global climate change? **Given an average of global carbon dioxide emissions scenarios…** Northern latitudes will ***likely*** continue to become wetter, while subtropical locations will ***likely*** grow even drier. The map shows likely warming by 2020–2029 (as well as by 2090–2099). Notice that northern latitudes are ***likely*** to experience a greater degree of warming. "A1B" is simply the IPCC's code for its "middle" ground emissions scenario. **Aim:** This slide aims to present projections of global climate change (that is, changes that are forecast to occur). **Key Points:** This slide is also fairly self-explanatory. It is important to convey uncertainty in a more direct manner by stating that such impacts ***are likely to occur but not a certainty***. More will follow on this in a later slide. **Graphics:** The word "likely" is in bold print in order to underscore how important it is to account for scientific uncertainty. Source citations: Intergovernmental Panel on Climate Change (IPCC). http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf Columbia University, Earth Institute. http://www.ldeo.columbia.edu/edu/dees/V1003/images/projected.CO2.temp.jpg
Slide 19		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"). Finally, Arctic Sea ice coverage is also ***likely*** to decrease even further (from approximately 7 million square-kilometers to 4 million square-kilometers) and will ***likely*** contribute to sea-level rises of 0.6–1.9 feet over the next century.

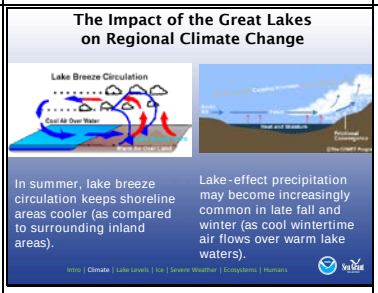
		Aim: This slide aims to present projections of global climate change (that is, changes that are forecast to occur). **Key Points:** This slide is also a fairly self-explanatory list. However, in this case, we are looking at a list of projected impacts, which scientists feel might result from continued global climate change. Thus, here it is important to convey uncertainty in a more direct manner by stating that such impacts ***are likely to occur but not a certainty***. More will follow on this in a later slide. **Graphics:** The word "likely" is in bold print in order to underscore how important it is to account for scientific uncertainty. Source citations: Intergovernmental Panel on Climate Change (IPCC). http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf Columbia University, Earth Institute. http://www.ldeo.columbia.edu/edu/dees/V1003/images/projected.CO2.temp.jpg
Slide 20		Using climate models, scientists have been able to demonstrate how increases in global average surface temperatures are not just a result of natural forces. Figure: As the blue band indicates, without human influences, global average temperature would actually have cooled slightly over recent decades. With human influences, it has risen strongly (black line), consistent with expectations from climate models (pink band). Source citation: This figure shows that climate models using only natural forces cannot replicate observed warming – in fact, they would predict cooling. Only models including anthropogenic greenhouse gases can duplicate the observed warming trend. (U.S. Global Change Research Program, Global Climate Change Impacts in the United States at 20 (2009).) http://downloads.globalchange.gov/usimpacts/pdfs/20page-highlights-brochure.pdf

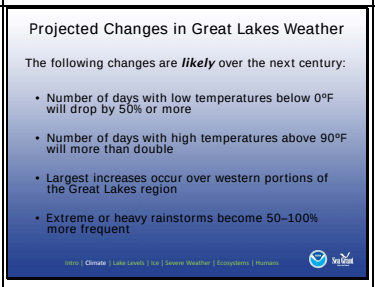
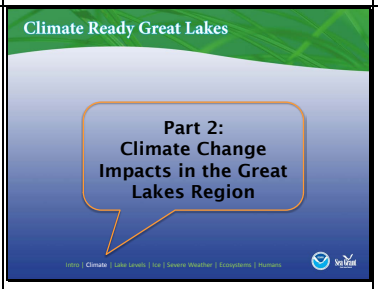
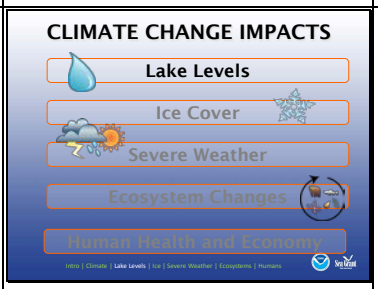
Slide 21		Global Climate Models also help us understand and quantify degrees of uncertainty associated with climate change forecasts. Climate change uncertainties include questions regarding the degree of future greenhouse gas emissions, solar output, and variations in ocean circulation patterns—and the complexities of the interactions between such variables. Our confidence in the ability of models to project future climate is growing.
Slide 22		This figure is a bit complicated at first glance; however, it is simply a depiction of what a climate 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—and 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. Source citation: ***Graphic sources unavailable at this time.***
Slide 23		Downscaling is a process of progression from a broad scale (in this case, global or national) to a narrower scale (such as regional or local). 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. **[CLICK]** Source citation: http://ccr.aos.wisc.edu/model/ipcc10min/futclimateinfo.html

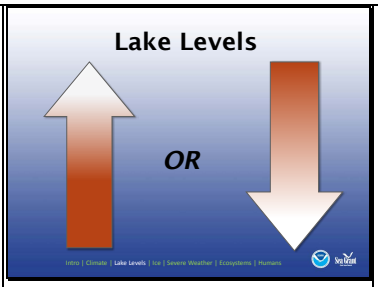
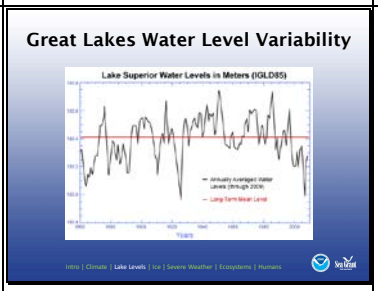
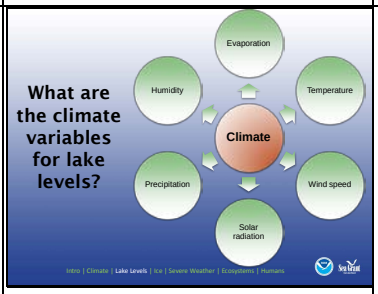
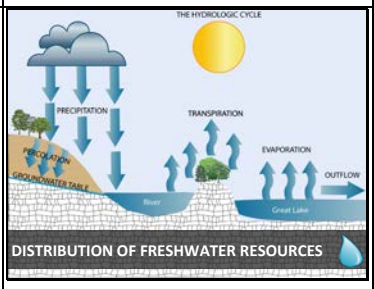
Slide 24		Why do we have to downscale global climate information to the regional scale? Global models don't have the resolution to handle things (such as mountains, valleys, and lakes) that have an impact on local and regional climates. Thus, the larger global climate projections must be adapted (statistically) 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.
Slide 25		So what makes regional climate change impacts for the Great Lakes different from **GLOBAL** climate change impacts?
Slide 26		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 represent 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…** **[CLICK]** 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. As a result, the climate is milder in portions of the basin as 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 they have recorded up to 350 inches of snow in a

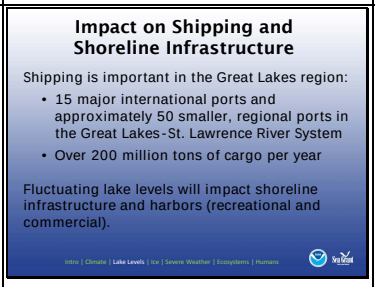
		single year. During the winter, the temperature of the lakes continues to drop. Ice frequently covers Lake Erie, but seldom fully covers the other lakes. We can see evidence of how the presence of the lakes impacts… …temperature climate in most areas (particularly east and south of the lakes, where its generally warmer in the winter and summer). **[Point to temperature along east and southern edges of the winter and summer slides.]** Notice how Lake Superior's southern shore is cooler (in the winter) than the land mass just south of it and warmer (in the summer) than the land mass north of it. ON WINTER SLIDE: In the winter, most lakes remain ice-free—except Erie, which is the shallowest of the lakes. … the length of the growing season along the shorelines. **[Point to frost free map to demonstrate how the length of the growing season increases closer to shore, because the lakes moderate the temperature around the shore.]** …precipitation. In winter, heavy snow bands occur along the eastern and southern shorelines. Lake impacts can even reduce summer precipitation downwind of the shore (due to stabilizing lake breeze effects). **[Point to precipitation and snow belts map to show how the air masses shown in the frost free map impact snowfall in the eastern and southern shoreline).** **[NEXT SLIDE]** Source: Environment Canada and U.S. Environmental Protection Agency. 1995. Great Lakes Atlas.

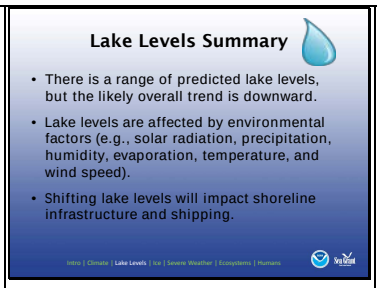
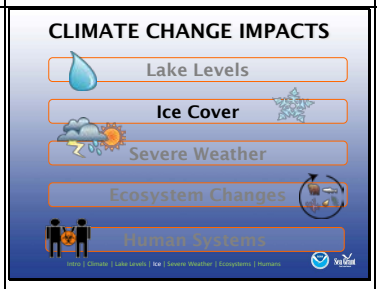
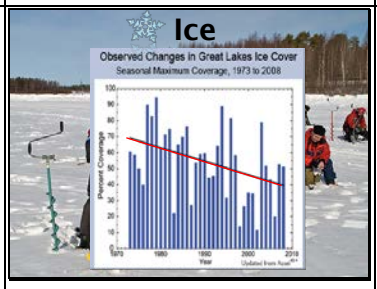
Slide 27		**Using climate models, scientists have made the following projections about changes in the Great Lakes <u>CLIMATE</u>…** Average surface temperatures are ***likely*** to rise another 3–6 degrees Celsius (5–10 degrees Fahrenheit) by 2100. Distribution of annual (yearly) average precipitation is ***likely*** to become increasingly uneven. In fact, the USGCRP predicts likely precipitation increases of 10–30% in wintertime and likely decreases of 5–25% in summertime. While annual average precipitation may increase slightly, lake levels could potentially drop as a result of increased evaporation (as a result of 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 the projected impacts of climate change in the Great Lakes region. It is important to recognize this slide is focusing on **climatological impacts** (such as changes to average temperatures, precipitation, and 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; thus, it is necessary to emphasize uncertainty in a more direct manner. Also, this slide lists four distinct impacts of climate change and shows a related figure that compliments each point (in-depth discussion below). **Figures:** The above figure provides an excellent snapshot of projected climate change impacts in the Great Lakes region. It offers excellent maps, which depict likely temperature and precipitation changes. Specifically, the figure directly relates to shifts in both temperature and precipitation (two of the four impacts discussed). The figure also indirectly explains both decreased water levels (which are related to increased evaporation due to warmer temperatures) and decreased lake ice coverage. (As average wintertime

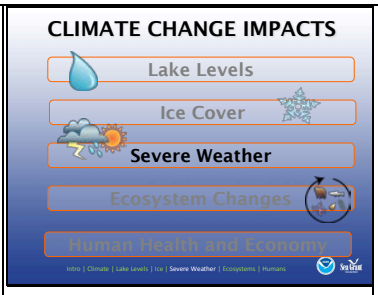
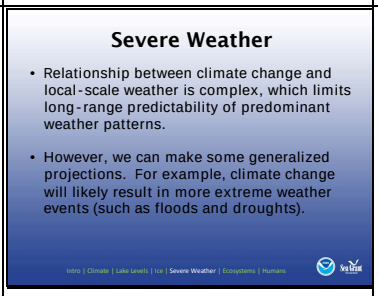
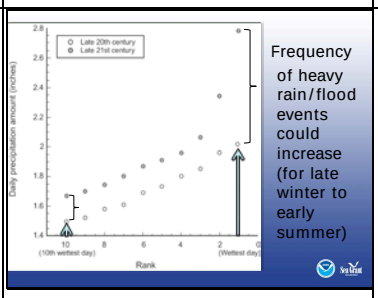
		temperatures rise—especially minimum temperatures—lake ice will not form as easily.) Furthermore, this figure is relatively easy to understand as well. The only potentially confusing point surrounds the depiction of projections from both the Canadian and Hadley models. Remind the audience of the fact that no projection is set in stone, and that different models help us to get a feel for the "range" of possibilities that exist. **Graphics:** As in earlier slides, the word "likely" is typed in bold print in order to emphasize uncertainty's importance. Image citation: United States Global Change Research Program (USGCRP). http://www.usgcrp.gov/usgcrp/Library/nationalassessment/LargerImages/RegionGraphics/Midwest/MWClimate.jpg
Slide 28		**The Great Lakes region is likely to experience changes as a result of climate change. However, in what ways might *the Great Lakes* themselves influence potential climate impacts?** The Great Lakes gain and lose heat more slowly that surrounding land masses. **CLICK. <u>Explain Lake Breeze Circulation diagram</u>: 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—as a place to "escape the heat." **[CLICK]** An increased difference between air and water temperatures in fall and early winter will ***likely*** lead to an increase in "lake-effect" precipitation. **[Point out graph on right:** Warmer summer temperatures heat up the lake in the summer. In winter, cold air moving across a 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.

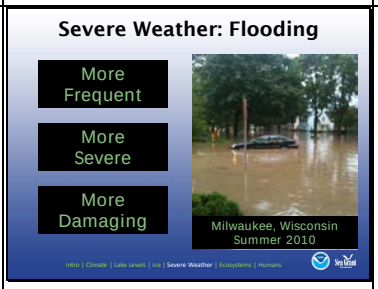
		These are simply examples of how weather, climate, and the lakes interact with each other.
Slide 29		**So, how will climate change interact with the lakes to alter daily <u>WEATHER</u> patterns over region? It's important to note that now we are talking about daily or weekly conditions—as opposed to the average changes mentioned in the previous slide.** **[READ FROM SLIDE]** **Aim:** This slide aims to summarize conditions that might become more prevalent over the Great Lakes region as climate change continues to play out. (Here we are talking about daily or weekly conditions, as opposed to the averages indicated in the previous slide.) **Key Points:** 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.
Slide 30		Now we're going to discuss, in more detail, the observed and projected impacts of climate change in the Great Lakes region.
Slide 31		For today's presentation, potential climate change impacts have been broken into six, somewhat interrelated categories. All of the categories are centered around the principle that climate change will have consequences for the Earth's system and human lives. Let's start with Lake Levels.

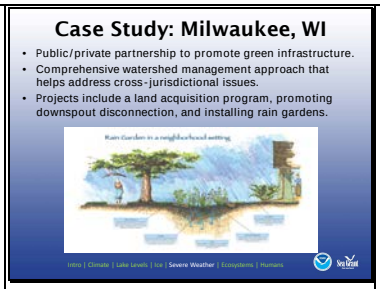
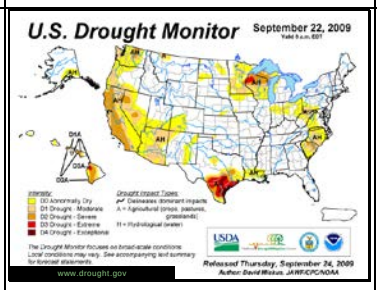
Slide 32		So, a big question is… will the level of the Great Lakes go up or down? **[WAIT FOR ANIMATED ARROWS TO COMPLETE]** There is still uncertainty about how exactly climate change will affect the levels of the Great Lakes. There is a range of predicted changes in lake levels over the next 50–100 years—with an overall downward trend in lake levels expected. However, that trend will be marked by significant variability and fluctuations due to changing climate variables that influence lake levels. Source citation: United States Global Change Research Program. *Global Change Impacts in the United States, Midwest Report*. http://www.globalchange.gov/images/cir/pdf/midwest.pdf
Slide 33		In fact, lake levels are already in a constant state of flux; the Great Lakes' water levels have varied considerably over the past several hundred years. As shown on this graph, over the last 150 years, Lake Superior has fluctuated about 2.6 feet (0.8 meters). The high water level in October of 1985 was 183.75 meters, and the low was in March of 1926 was 182.95 meters. Source citation: The data in this graph originated from the U.S. Army Corps of Engineers-Detroit District.
Slide 34		The natural variation in lake levels is influenced by many environmental factors, including 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.
Slide 35		To understand how lake levels 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, which goes back into the atmosphere through transpiration; moisture is also returned to the atmosphere through evaporation from water bodies. Greater evaporation will result from (1) warmer temperatures in the summer and (2) less ice cover in the winter. As more water leaves the lakes and enters the atmosphere, there is the potential for

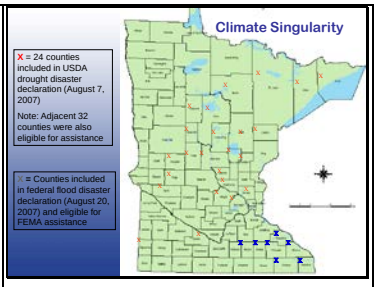
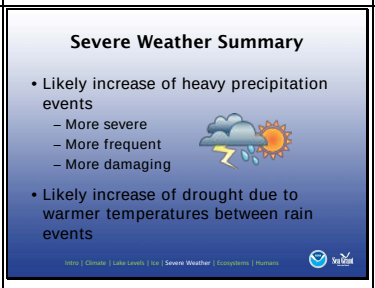
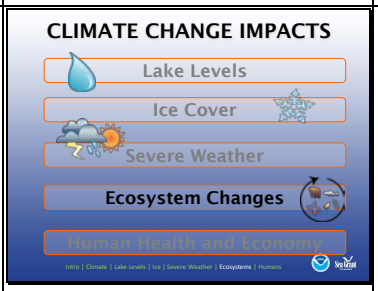
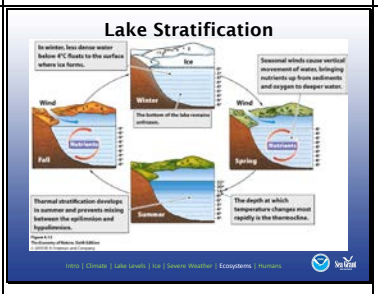
		water levels to drop—if all else is held constant in the environment. Based on most peer-reviewed studies, scientists currently believe that lake levels will fall over the next century. However, there will continue be a great deal of year-to-year fluctuation or variability. Source citation: United States Global Change Research Program. *Global Change Impacts in the United States, Midwest Report.* http://www.globalchange.gov/images/cir/pdf/midwest.pdf
Slide 36		**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. These ports ship 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. Source citations: Great Lakes Commission and NOAA Coastal Services Center. August 18, 2006. *Great Lakes Needs Assessment Ports and Navigation. Final Draft Interim Report.* http://www.glc.org/regionalneeds/. Savonis, Michael J., Virginia R. Burkett, 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. 2008. "The Potential Impact of Climate Change on U.S. Transportation." *Transportation Research Board Special Report 290*. Transportation Research Board: Washington, D.C.

Slide 37		
Slide 38		Now let's talk about how climate change will impact ice cover on the Great Lakes.
Slide 39		One predicted impact of rising temperatures in the Great Lakes is a reduction in seasonal ice cover. **[CLICK]** While this graph of ice cover in the Great Lakes 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, just to recap, we've talked about lake level changes, projected temperature increases, and a reduction in ice coverage on the lakes. Source citation: United States Global Change Research Program. *Global Change Impacts in the United States, Midwest Report.* http://www.globalchange.gov/images/cir/pdf/midwest.pdf Image citations: •http://www.flickr.com/photos/henribonell/3376075968/sizes/m/ •http://www.flickr.com/photos/javatopia1/106474947/ **Backup** Relate to snow cover: Isard et al. found that one impact of ice cover change is a 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.

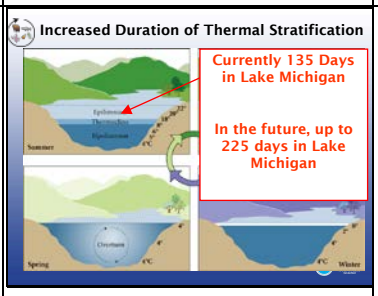
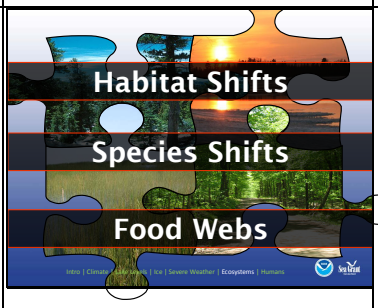
Slide 40		Now let's discuss how climate change may affect severe weather patterns in the Great Lakes region.
Slide 41		While climate change is unequivocal and always occurring, the relationship between climate change and local weather is complex. These complexities limit the long-range predictability of predominant weather patterns. However, we can 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 floods and droughts).
Slide 42		More extreme weather events mean the frequency of heavy rain and flood events will likely increase (in late winter to early summer), due to increases in atmospheric heat and moisture capacity over the region. One recent study on future weather patterns in Southern Wisconsin concluded that the area 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 (the open circles) and in the late 21st century (the grey, filled in circles). The horizontal axis shows the 10 wettest days of the year, while the vertical axis shows the theoretical daily precipitation amounts. **[CLICK so that 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 so that 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; however, at the end of the 21st century, that amount would increased to more than 2 ¾ inches of

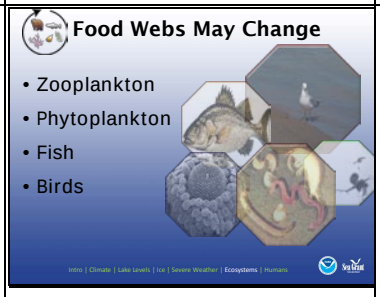
		rainfall. Source citation: Patz, Jonathan A., Stephen J. Vavrus, Christopher K. Uejio, Sandra L. McLellan. 2008. "Climate Change and Waterborne Disease Risk in the Great Lakes Region of the U.S." *American Journal of Preventative Medicine* 35 (5): 451-458.
Slide 43		Extreme weather events are high amounts of precipitation within a short period of time. 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. Increases in precipitation accumulations has been the greatest in the Great Lakes, Southwest, and Midwest regions of the United States. One recent example in the Great Lakes region is the flooding that occurred in Milwaukee, Wisconsin, in July 2010. 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 cleanup, increased maintenance costs, and increased water treatment costs. Source citations: 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."

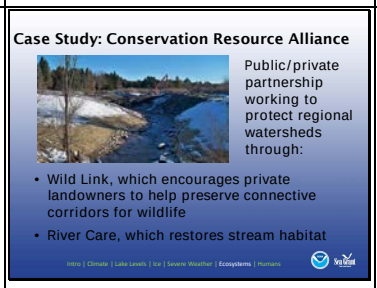
Slide 44		One example of a community dealing with extreme weather is Milwaukee, Wisconsin. The city works with the Southeastern Wisconsin Watershed Trust to promote green infrastructure to help with more intense rain events. The partnership uses a comprehensive watershed management approach that helps address cross-jurisdictional issues (such as those 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. Source citations: "Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions." Center for Clean Air Policy. pp.19. (In M2 folder.) NOAA Adaptation Guide. pp. 51. http://v3.mmsd.com/ Image citation: http://www.sleepycreekwatershedassociation.org/Content/StormWaterMgmt/rain_gardens.htm
Slide 45		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 drought.gov. Source: http://www.drought.gov/portal/server.pt/community/drought_gov/202;jsessionid=C426B88FFC8230487C75790E640B7884

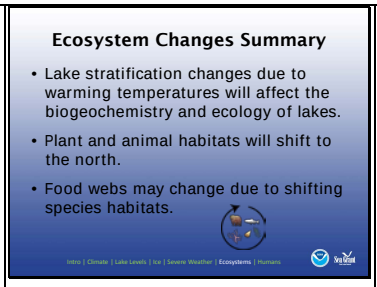
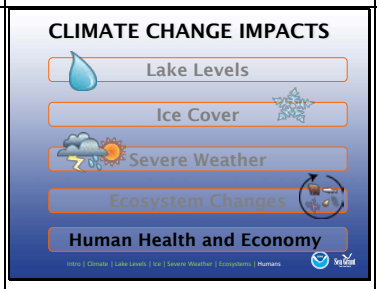
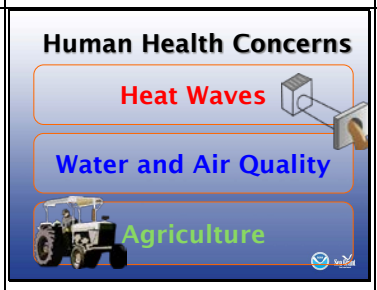
Slide 46		The Great Lakes region is already experiencing extreme weather events, which demonstrates the increased variability we will experience from climate change. For example, in August 2007, several Minnesota counties experienced drought conditions—while at the same time neighboring counties were experiencing flooding. Drought and flood conditions happening at the same time and in the same region point to the need for states to develop response plans for a variety of extreme weather events that occur simultaneously. Image citation: Mark Seeley. University of Minnesota Extension Climatologist.
Slide 47		
Slide 48		Now that we've talked about impacts on severe weather events, let's consider some ways that the Great Lakes ecosystem might be affected by climate change.
Slide 49		**So, how will climate change affect Great Lake ecosystems?** In order to understand how these changes would be possible, let's first review the process of lake stratification to see how temperature and wind contribute to the seasonal differences we observe in the Great Lakes themselves. Climate change will affect stratification of the lakes, which in turn impacts lake ecosystems. Stratification refers to a change in the water temperature at different depths in the lake, which is due to the change in the density (or weight) of water with temperature. An interesting characteristic of water is that its maximum

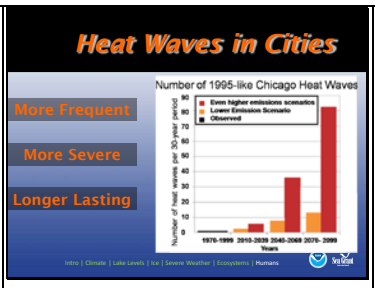
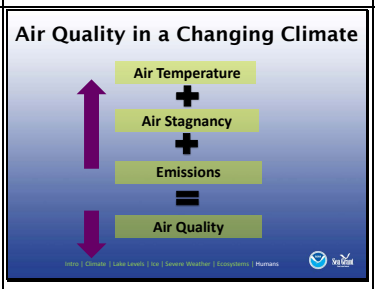
		density is at 4°C. Water that is colder than 4°C is therefore less dense, causing it to float to the surface where ice forms. In the spring, water warms as the ice melts, and winds cause water to mix (bringing nutrients up from sediments at the bottom and oxygen down to deeper water). This is called the spring turnover. In the summer, the temperature difference between warmer waters at the surface and cooler waters below is great enough to prevent the different parts of the water from mixing (due to differences in density). This is called summer stratification. In the fall, surface water cools again to a point where the the water has the same density at all depths. This allows it to mix again. In the winter, ice forms a barrier on top of the water, which prevents mixing from occurring. In the Great Lakes region, a cyclical pattern of overturn occurs as the water warms and cools through the seasons. This process affects the biogeochemistry and ecology of the lake. This process will be impacted 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. Source citations: 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.

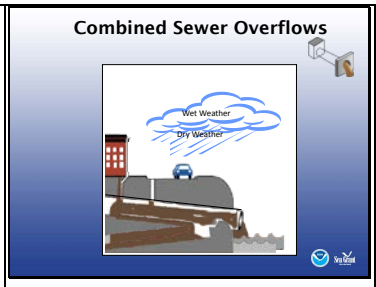
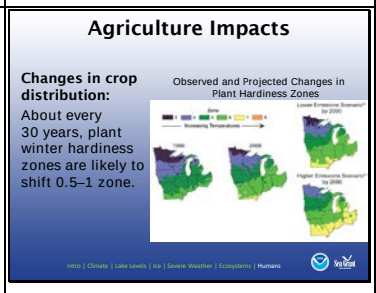
		www.agu.org/pubs/crossref/2007/2006GL029021.shtml Austin, J.A. and S.M. Colman. 2008. "A century of temperature variability in Lake Superior." *Limnol. Oceanogr.* 53, 2724–2730. www.aslo.org/lo/pdf/vol_53/issue_6/2724.pdf
Slide 50		Today, thermal stratification lasts about 135 days. Under some climate change scenarios, the period of thermal stratification could reach 225 days by the end of the century! **[CLICK]** 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.
Slide 51		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, 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. For example, as habitats become drier, species may shift to remain in their preferred temperature range. These shifts can alter the relationships between species and how they use their habitats. Image citations: 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

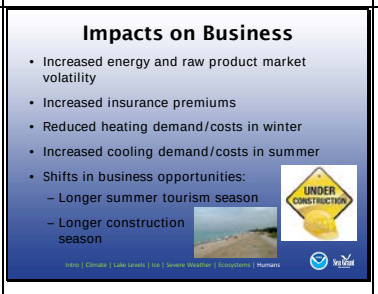
Slide 52		One of the major impacts of rising temperatures in the Great Lakes region will be shifts and expansion of species to the north. Numerous studies are documenting movements by species as they seek out the best conditions for their survival. **[CLICK]** Small mouth bass are an example of a warm-water 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. **[CLICK]** A recent study tracking small mammals in Michigan found that the 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. **[CLICK]** 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, because they are sensitive to water levels and hydrology. Citation: http://www.ucsusa.org/greatlakes/glregionmic_fis.html
Slide 53		We can expect climate change to disrupt food webs in the Great Lakes, because of species shifts, habitat changes, and a lengthening of the thermal stratification period. 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. Phytoplankton is at the base of the food web. Changes in the availability of phytoplankton (due 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 components may be equally sensitive to warmer

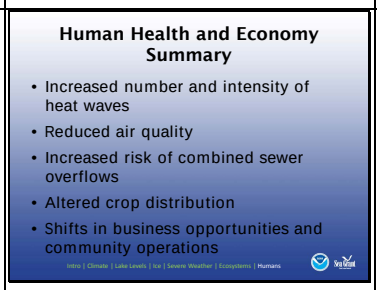
		temperatures or lower water levels. So, species that shift their geographic distribution may also need to shift their diets. Changes in habitat conditions and disruptions to food webs may also increase the vulnerability of the Great Lakes to invasive species. Source citation: Confronting Climate Change in the Great Lakes Region - Impacts on Our Communities and Ecosystems, The Union of Concerned Scientists and The Ecological Society of America, 2005, http://www.ucsusa.org/assets/documents/global_warming/gl-exec-summary-update-05-doc.pdf Pictures: Sources Unknown
Slide 54		An example of a community responding to ecosystem changes is the Conservation Resource Alliance (CRA), set in Northwest Lower Michigan, which 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 to 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. 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 image above shows removal of the aging Wheeler Creek Dam taking place, allowing Wheeler Creek to flow freely into the Manistee River (courtesy rivercare.org). Source citation: http://www.greeninfrastructure.net/sites/greeninfrastructure.net/files/5-CRA%2008.30.05_0.pdf

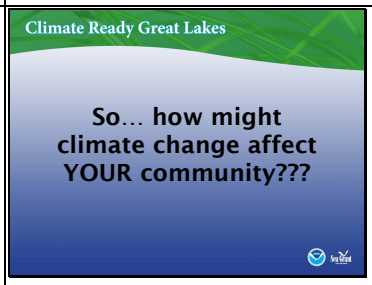
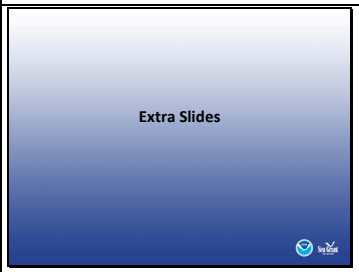
Slide 55		
Slide 56		Humans are an integral part of Great Lakes ecosystems. Let's also talk about how human health and welfare might be affected by climate change.
Slide 57		We're going to talk about three concerns of specific interest in the Great Lakes: the effect of extreme weather on human health, the effect of climate change on water quality and disease, and the effects of climate change on agriculture.
Slide 58		We'll start with the impacts of heat waves on human health. Some of you may not know that extreme heat is the natural hazard that kills far more people than any other. In July of 1995, a severe, week-long heat wave hit Chicago. Image citation: *Chicago Tribune.*

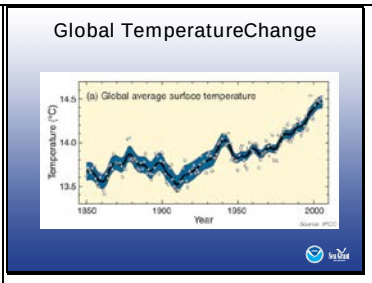
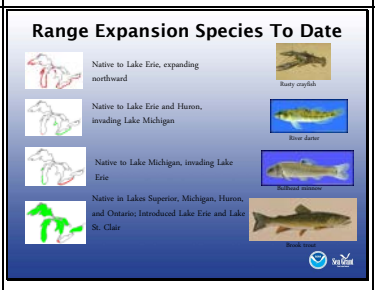
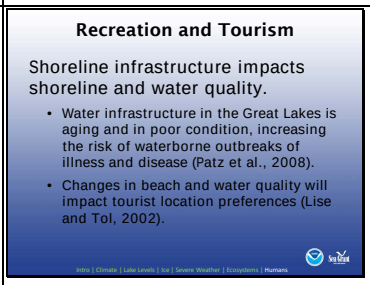
Slide 59		Temperatures peaked at 106 degrees Fahrenheit, with a heat index of 126 degrees. The use of electricity skyrocketed, resulting in power grid failures throughout the city. This was one of the worst weather-related disasters in Illinois history; 525 people died over a 5-day period. **[CLICK to bring up red map]** More frequent, extreme heat events are expected over the next century as a result of climate change. By 2080, the Midwest might see extreme heat events every three years. 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. 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 citation:http://downloads.globalchange.gov/usimpacts/pdfs/midwest.pdf and http://www.thedailygreen.com/environmental-news/latest/heat-waves-47121801#ixzz0TkpwKSSU<http://www.thedailygreen.com/environmental-news/latest/heat-waves-47121801>
Slide 60		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. Source citation: Wu, Shiliang, Loretta J. Mickley, Eric M. Leibensperger, Daniel J. Jacob, David Rind, and David G. Streets. 2008. "Effects of 2000–2050 global change on ozone air quality in the United States." *Journal of Geophysical Research*, 113, D06302, doi:10.1029/2007JD008917.

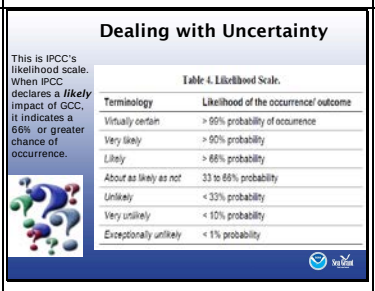
Slide 61		Climate change is also expected to have an impact on water quality. For example, we've noted that the frequency of heavy rain events will increase with climate change. During storms, combined sewer overflows can cause sewage to flow into lakes. How does this happen? Combined sewer systems collect 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. **[CLICK]** But, during big storms, the plants can't handle the volume—and the systems are designed to overflow into lakes.
Slide 62		When over a billion gallons of sewage is released into our rivers and lakes from combined sewer overflows during heavy rains, water quality diminishes and beaches are closed Combined sewer overflows 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. Of the 801 cities in the United States with active combined sewage systems, 65% are in Great Lakes states. NOAA scientists are improving their capabilities to forecast and warn people of poor water quality after storms. Source citation: Picture Unknown
Slide 63		Climate change will also impact agriculture. For the Great Lakes agriculture community, this is good 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. Source citations:

		Preparing for Climate Change: A Guidebook for Local, Regional and State Governments. http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf United States Global Change Research Program. *Global Change Impacts in the United States, Midwest Report*. http://www.globalchange.gov/images/cir/pdf/midwest.pdf
Slide 64		Changes in climate are expected to impact crop yields. Several studies report that corn and soybean growing areas will shift north, and another study found that commercial fruit growing conditions will improve near the coasts of the Great Lakes. It is also anticipated that a longer, warmer growing season will lead to an increased demand for water and, possibly, an increased risk of heat stress for crops. On the flip side, longer growing seasons for crops also provide longer growing seasons for not-so-economically-important organisms (such as weeds and pests). **[CLICK]** Insect populations that have historically been controlled by cold winters will be more likely to survive during milder winters, which may mean larger populations in a warmer climate. 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.
Slide 65		Finally, climate change is expected to impact business operations in the Great Lakes region by providing both challenges and opportunities, including: Increased energy and raw product market volatility due to more extreme weather events Increased insurance premiums due to more extreme weather events Reduced heating demand and lower heating bills in the winter Increased cooling demand and higher cooling bills in the summer Shifts in business opportunities (for example, there will be a longer summer vacation season and a longer

		construction season) **Source citation:** *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments.* http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf **Potential resource:** *Economic Impact Analysis of Climate Change for the City of Chicago* Image citations:greatlakesdayindc.blogspot.com auburn.edu
Slide 66		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, and golfing). 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 of need for an expanded Parks and Recreation Department to deal with an increase in summer tourism activities. Image citations: nwk.usace.army.mil snowremovalservice.org
Slide 67		

Slide 68		Let's review what we have heard so far. **[Pause to let people read about our understanding, then [CLICK]]** The Great Lakes will have different and distinct climate challenges and opportunities compared to the rest of the country. 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, severe weather may bring hurricanes, but 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.
Slide 69		
Slide 70		

Slide 71		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 0.13^{o}C per decade, which is nearly twice as much as the increase over the last 100 years. Source citation: 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 citation: http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains1.html
Slide 72		
Slide 73		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. Source citations: 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. 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." *Climatic Change* 55:429–449. Great Lakes Beach Association in cooperation with National Oceanic and Atmospheric Association, United States Environmental Protection Agency, and US Geological Survey.

		Report on Great Lakes Beach Health Research Needs Workshop of November, 4, 2005. Sturtevant, Rochelle. 2004. "Great Lakes Ecological Forecasting Needs Assessment." *NOAA Technical Memorandum GLERL-131*. Great Lakes Environmental Research Laboratory: Ann Arbor, MI.
Slide 74		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 socioeconomic information produced worldwide relevant to the understanding of climate change. One primary activity of IPCC is regularly publishing special reports or assessments of climate change and its impacts. In their reports, IPCC uses a likelihood scale to describe the probability of occurrence for an event. When IPCC declares a ***likely*** impact of global climate change (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—and climate research is 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. Image citations: Wesleyan Student Assembly (WSA). http://wsa.wesleyan.edu/wp-content/uploads/Question-Marks.jpg Intergovernmental Panel on Climate Change (IPCC). http://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf National Aeronautics and Space Administration (NASA). http://climate.nasa.gov/uncertainties/

CLIMATE READY GREAT LAKES: MODULE 2 – DEVELOPING A CLIMATE ADAPTATION PLAN

AN OVERVIEW OF PLANNING PROCESSES AND STRATEGIES FOR CLIMATE CHANGE ADAPTATION

SCOPE

This module introduces participants to processes for developing an adaptation plan, as well as some strategies for adaptation that can be included in such a plan. The module was designed to assist decision makers who are interested in adaptation planning for climate change but have not yet begun to develop an adaptation plan.

GOALS

1. Participants will know what an adaptation plan is.
2. Participants will be aware of some strategies for climate adaptation.

OBJECTIVES

By the end of the training:

1. Participants will understand what an adaptation plan is.
2. Participants will understand the value of collaboration in adaptation planning (regional, or across watersheds, etc. depending on specific communities).
3. Participants will be able to identify the concrete steps in developing an adaptation plan.
4. Participants will demonstrate ability to apply the adaptation planning process to a specific climate change impact.

MODULE 2: OUTLINE

Part I: How to Develop an Adaptation Plan

1. Climate Change Impacts in the Great Lakes Region
2. What is an Adaptation Plan
3. The Planning Process
    a. Establish Process
    b. Assess Vulnerability
    c. Select Strategies
    d. Implementation and Updating

Part II: Strategies for Adaptation

1. Water Management
    a. Stormwater Management
    b. Flood Prevention
2. Drought
3. Infrastructure
    a. Building Codes and Zoning
    b. Ports and Marinas
    c. Shoreline Management
    d. Transportation: Roads
    e. Energy
4. Ecosystem Resilience
5. Urban Heat Islands
6. Financial and Regulatory Incentives

WORKSHEET: ASSESSING VULNERABILITIES

Directions: Identify three 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**. Then complete the table below.

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

A. Climate change impact:

1.

2.

3.

B. Effects on community:

1.

2.

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?			

WORKSHEET: 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 the previous Worksheet (*Assessing Vulnerabilities*) and 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.

Example: *If stormwater management is a concern, perhaps you would select "green infrastructure" as one promising strategy.*

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 (from prev. Worksheet)	**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?)			

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)

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

OTHER POTENTIAL SOURCES FOR PLANNING TEAM MEMBERS AND SUPPORTERS:

- 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
- Research institutions
- Infrastructure managers
- Industries (tourism, fisheries, oil and gas, shipping, etc.)
- Contractors/engineers
- Developers
- General public

PLANNING PROCESS:
STEPS FOR DEVELOPING AN 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 non-climatic 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 are that the action is based on
- 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.

Source: *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. National Oceanic and Atmospheric Administration, 2010. http://coastalmanagement.noaa.gov/climate/docs/adaptationguide.pdf

ADAPTATION PLANNING: CASE STUDIES (OVERVIEW)

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. 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]

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.[4]

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 Program helps local citizens restore trout stream habitat damaged by 19th and 20th century logging.[5]

---

[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.greeninfrastructure.net/sites/greeninfrastructure.net/files/4-FINALSag%20Bay%2007.18.05.pdf

[5] http://www.greeninfrastructure.net/sites/greeninfrastructure.net/files/5-CRA%2008.30.05_0.pdf

Long-term Implementation Through Public Participation (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.[6]

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.[7]

Downspout Disconnection Program (Toronto, Ontario) – All Toronto homeowners are required to disconnect their downspouts that had been connected to the combined sewer system.[8]

Discounted Rain Barrels (Milwaukee, Wisconsin) – The city purchased rain barrels in bulk and sold them at discounted prices to residents.[9]

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.[10]

Protecting Groundwater Recharge Areas (Austin, Texas) – The city uses conservation easements and the purchase of development rights to protect groundwater recharge areas.[11]

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.[12]

Comprehensive Policy Revision (Olympia, Washington) –Revision of multiple aspects of planning and development, including development density, impervious surfaces, lot size, open space/tree retention, street design and width, block size, parking, sidewalks, and stormwater management requirements.[13]

---

[6] 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.

[7] http://www.a2gov.org/government/publicservices/systems_planning/waterresources/Pages/StormWater.aspx

[8] http://www.toronto.ca/water/protecting_quality/downspout.htm

[9] http://v2.mmsd.com/RainBarrels.aspx

[10] For more information, see http://egov.cityofchicago.org/city

[11] http://www.ci.austin.tx.us/water/wildland/default.htm

[12] http:www.conservationfund.org/node/404

[13] http://www.psparchives.com/publications/our_work/stormwater/lid/ordinances/Green_Cove.pdf

ADAPTATION PLANNING: CASE STUDIES (DETAIL)

PLANNING PROCESSES

Connecting to Existing Planning Processes (Marin County, CA) [1]

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.

[1] American Planning Association. 2010. *Planning for a New Energy and Climate Future* pp. 50-51

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

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."[2] 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.[3]

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,

[2] 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.

[3] 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.

yet could be understood by the "informed public" and decision makers, and therefore could be used in discussions about remedial activity.[4]

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)

Economic Analysis of Options (Fox-Wolf River Basin and Green Bay, WI)[5]

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.

---

[4] 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.

[5] 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.

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.

ECOLOGICAL RESILIENCY

Regional Collaboration (Saginaw Bay, Michigan) [6]

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.

[6] 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)[7]

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.

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

[7] 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

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

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. [8]

[8] This text is copied from the abstract of the paper: Krantzberg, Gail. "Sustaining the Gains Made in Ecological Restoration: Case Study Collingwood Harbour, Ontario." *Environment, Development and Sustainability* (2006) 8: 413–424

STORMWATER CONTROL MEASURES

SCM	What it Accomplishes	What it Replaces	How it Works
Bioswales	Runoff Reduction	Curb/gutter and storm drainpipes	Shallow, well-drained bioretention swales that help remove silt and pollutants
Wet and Dry Ponds	Runoff Reduction	Positive drainage from impervious surfaces to gutter	Grading front yard to treat roof, lawn, and driveway runoff using shallow bioretention
Stormwater Wetlands	Peak reduction and runoff treatment	Large detention ponds	Long, multi-cell, forested wetlands located in the stormwater conveyance system
Green Roofs	Runoff reduction	Concrete roofs	Use of vegetation on a roof, placed over a waterproofing membrane, to absorb rainwater as it falls
Pervious Pavement	Increase permeability of impervious cover	Hard asphalt or concrete	Use of permeable pavers, porous concrete, and similar products to decrease runoff generation from parking lots and other hard surfaces
Earthwork Minimization	Conservation of soils and contours	Mass grading and soil compaction	Construction practices to conserve soil structure and only disturb a small site footprint
Watershed Planning	Off-site stormwater treatment or mitigation	On-site waivers	Stormwater retrofits or restoration projects elsewhere in the watershed to compensate for stormwater requirements that cannot be met onsite
Conservation of Natural Areas/Reforestation	Maximize forest canopy and green space	Mass clearing	Preservation of priority forests and reforestation of turf areas to intercept rainfall
Impervious Cover Minimization	Runoff reduction	Large streets, lots and cul-de-sacs	Narrower streets, permeable driveways, clustering lots, and other actions to reduce site impervious cover

Adapted from: *Urban Stormwater Management in the United States*, National Research Council Report. The National Academies Press, Washington, D.C., 2008.

Workshop Evaluation: Climate Ready Great Lakes

Module 2: Developing an Adaptation Plan

Directions: Please read carefully and respond to the following questions:

1) How much has this presentation improved your understanding of climate adaptation planning? (Check one.)

☐ Greatly improved	☐ Somewhat improved	☐ Slightly improved	☐ No change

2) How valuable do you feel collaboration is as a part of the planning process?

☐ Very valuable	☐ Somewhat valuable	☐ Slightly valuable	☐ Not at all valuable

3) Identify the four steps in developing an adaptation plan:
   a.
   b.
   c.
   d.

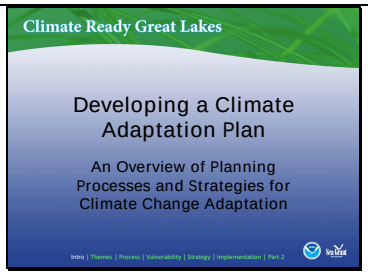
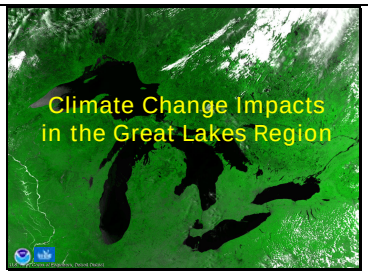
4) Identify strategies your community could use that would be helpful in adapting to climate change:
   a.
   b.
   c.

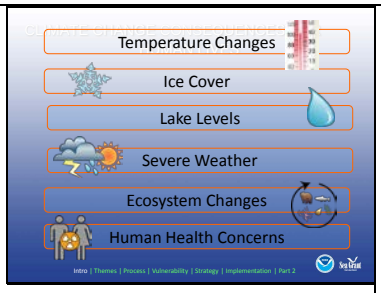
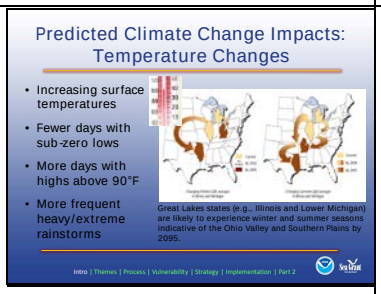
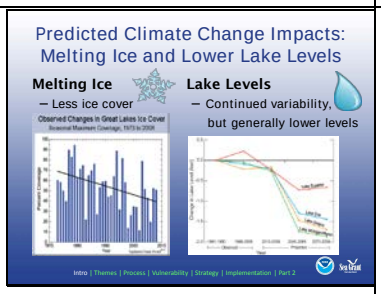
5) Did you find this module's worksheets useful?

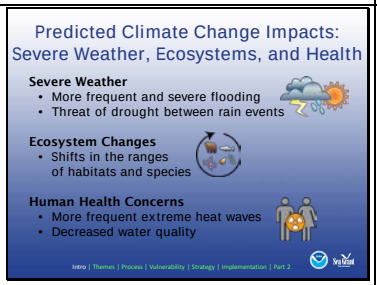
☐ Very useful	☐ Somewhat useful	☐ Slightly useful	☐ Not at all useful

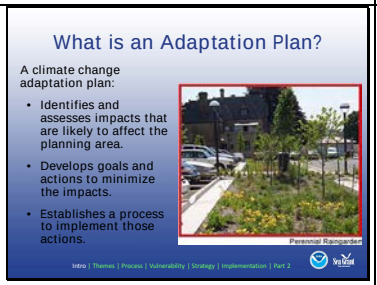
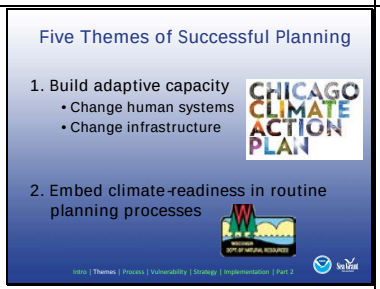
6) Additional comments…

MODULE 2: SLIDES AND NOTES

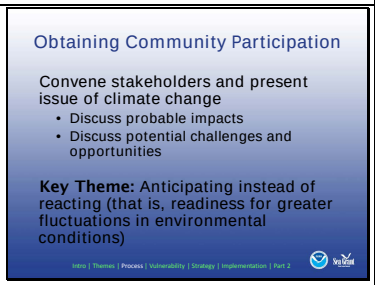
Slide 1		Welcome to this training on "Climate Ready Great Lakes!" This presentation features content that was developed on behalf of the NOAA Great Lakes Regional Collaboration Team and the Great Lakes Sea Grant Network.
Slide 2		This is the second of three modules developed to help people and communities in the Great Lakes region become more "climate ready." This module provides an introduction to developing a climate adaptation plan.
Slide 3		This 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 will include insights from real world case studies. 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.
Slide 4		The following slides provide a brief review of the predicted impacts of climate change in the Great Lakes Region.

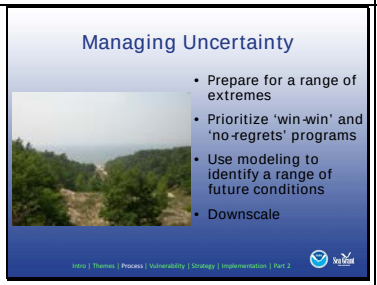
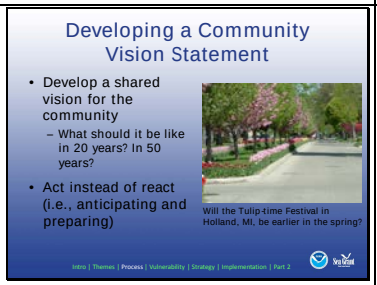
Slide 5		Climate change is a global phenomenon, but its effects are seen at a regional scale. There is a wealth of knowledge about climate systems, but regional-scale systems are still under development and require improvements in scale and certainty. However, it is clear that… **Climate change will have consequences for the Earth system and human lives.**
Slide 6		• 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 Lower 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
Slide 7		As ice sheets and glaciers melt and seawater thermally expands (as the oceans warm), it is causing the sea level to rise globally. Although there are no ice sheets or glaciers in the Great Lakes, a reduction in seasonal ice cover 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

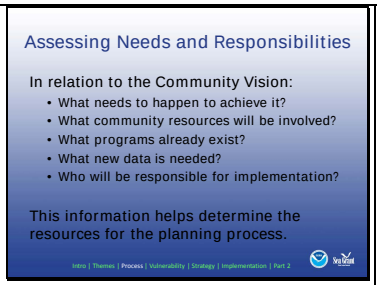
		scenario, water levels in the Great Lakes are projected to fall no more than 1 foot by the end of the century; however, they are projected to fall 1–2 feet in a higher emissions scenario. The greater the temperature rise, the higher the likelihood of a larger decrease in lake levels. Climate factors 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 citation: United States Global Change Research Program. *Global Change Impacts in the United States, Midwest Report.* http://www.globalchange.gov/images/cir/pdf/midwest.pdf
Slide 8		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.

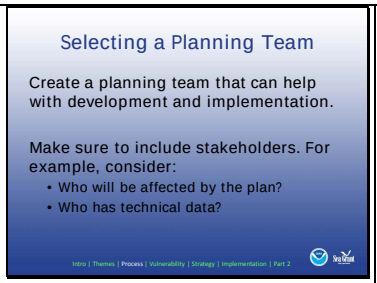
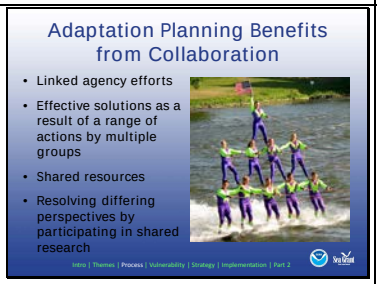
		The Great Lakes region includes numerous ecosystems and habitats (such as coastal wetlands, northern hardwood and coniferous forests, beaches, and dunes). Many of these habitats have been stressed or altered by human activities over time. Additionally, relatively small changes in temperature or water 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.
Slide 9		"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*.)
Slide 10		Chicago has worked extensively to prepare for climate adaptation, including documenting the planning process they used. 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.

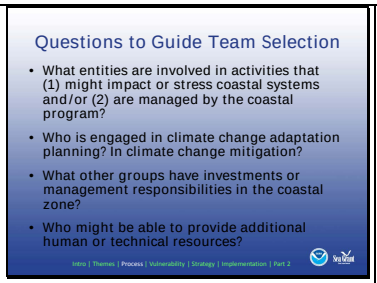
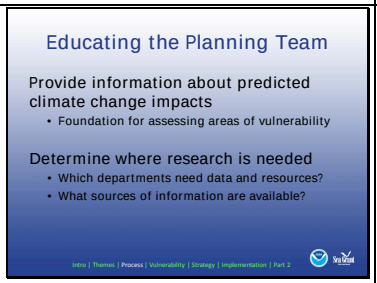
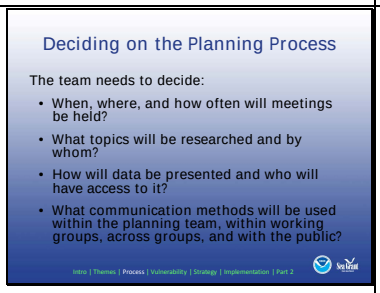
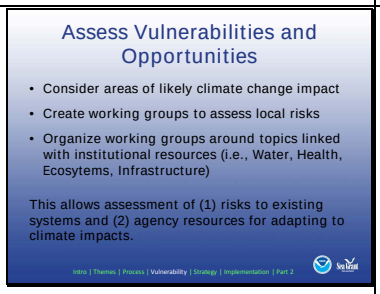
		The *Chicago Climate Action Plan* includes five themes for successful planning that are useful for all planners to keep in mind: 2) "[B]uilding adaptive capacity is the putting in place of support systems, data collection, evaluation processes, awareness-raising, and policy framework(s) which will encourage, 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." 3) 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. 4) 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.

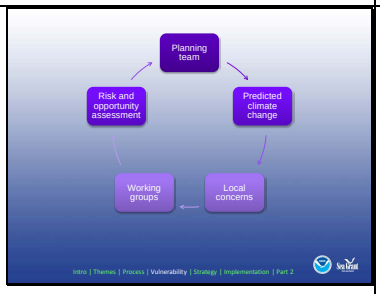
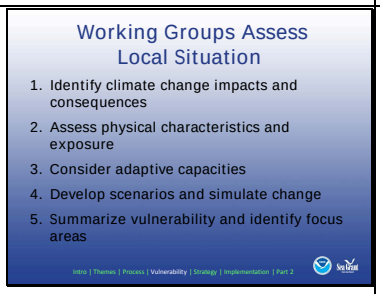
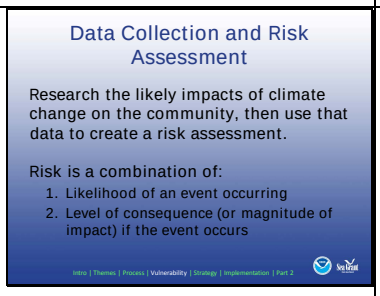
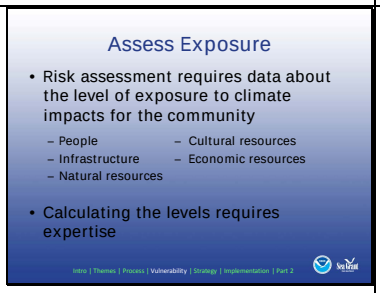
Slide 11		5) Adaptation measures almost always have multiple benefits (such as reduced energy costs, improved aesthetics, and reduced air and water pollution). These should be considered to assess the overall benefit of the measures that may be taken—especially when the co-benefits either save money or outweigh the costs of the measures. *Chicago Quick Guide to Climate Change Preparation*
Slide 12		6) 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. Also, distributed infrastructure can be more flexible in responding to change than large, centralized systems. 7) "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*
Slide 13		This adaptation planning process is from NOAA's *Adapting to Climate Change: A Planning Guide.* 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.
Slide 14		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,

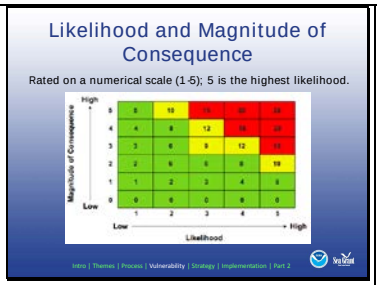
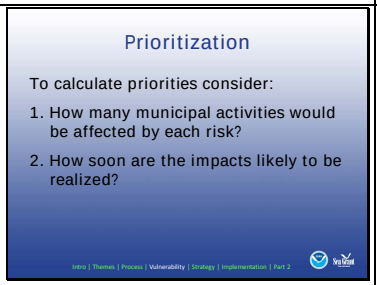
		• Preparing strategies for competition for water in dry years • Avoiding land use/development with problematic consequences • Preventing development in shorelines exposed by low water
Slide 15		Waiting until information is completely certain increases risk, so climate change planning requires action 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.
Slide 16		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: David MacNeil – Sea Grant PowerPoint
Slide 17		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. *Anticipating* includes planning to avoid potential future conflicts, such as: • Competition for water in dry years • Land use/development with problematic consequences • Development in shorelines exposed by low water • Future shoreline ownership issues

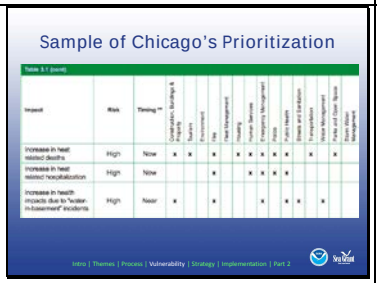
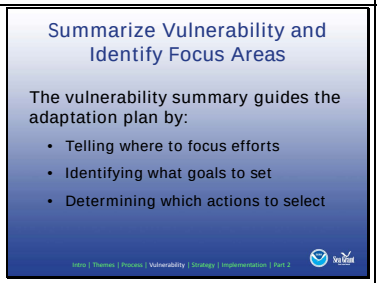
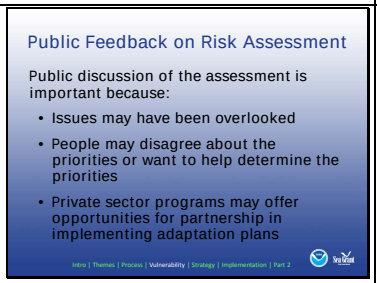
Slide 18		It is important to be clear about (1) what the plan aims to accomplish and (2) who needs to be included in the process in order to accomplish it. Figuring this out at the beginning of the process saves trouble later. For example, Chicago began its planning process with the idea that the Department 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
Slide 19		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.

Slide 20		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.)*
Slide 21		Collaboration is appropriate for climate adaptation planning processes. Implementation of the plan will require cooperation across agencies and authority parameters; perceived ownership of the issues and resources is an important motivation for participation. 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.

Slide 22		From NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*
Slide 23		The team needs knowledge about the predicted local impacts of climate change in order to determine what topics need to be researched further.
Slide 24		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.
Slide 25		This adaptation planning process is from NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*
Slide 26		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

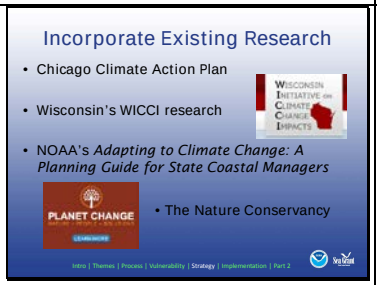
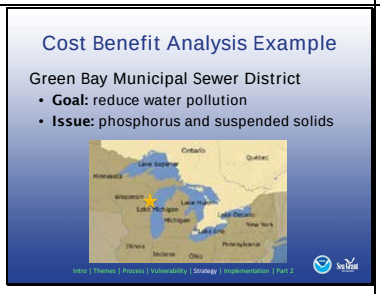
		agriculture. • Infrastructure's subthemes included heating and cooling, operation and maintenance, labor, and other. Although the primary focus of adaptation planning is on risks, climate change may also create new opportunities for a community. Including this concept in the research gives a more complete picture that is useful in determining the best local actions.
Slide 27		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.
Slide 28		From NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers*.
Slide 29		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*.
Slide 30		The data that the working groups collect will provide this assessment. Module 3 describes tools and resources to help calculate the levels of exposure.

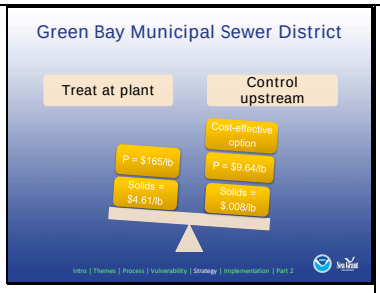
Slide 31		This chart is an example of a way to visualize a risk assessment used by Chicago. The use of 0 on the consequence scale to indicate beneficial impacts did not prove useful. Other communities might want to create a separate measure for benefits/opportunities related to climate change impacts. 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. 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)
Slide 32		8) 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. 9) 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

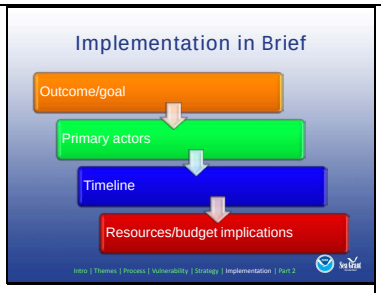
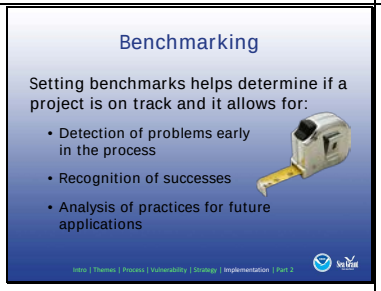
		address impacts that are lower on the priority list may appear. For instance, these could be tied to current development or government grants that will expire shortly. Cases like these will have to be evaluated on an *ad hoc* basis.
Slide 33		** Timing categories: Now = 2010, Near = 2010-2039, and Mid = 2040-2069. Notice how many categories of municipal activity are being affected by the impact of increased heat.
Slide 34		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 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.*
Slide 35		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

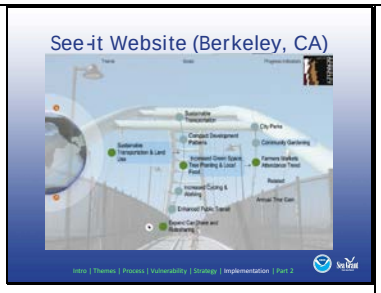
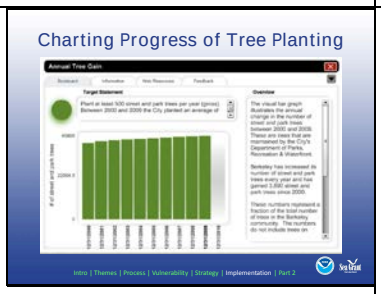
		process and feel that the resulting priorities are valid, they will be more likely to support the adaptation plans. • There may be small-scale programs within the private sector that offer opportunity for partnership in implementing adaptation plans.
Slide 36		This adaptation planning process is from NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers.*
Slide 37		10) 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. 11) 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. 12) 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. 13) The highest priorities have already been

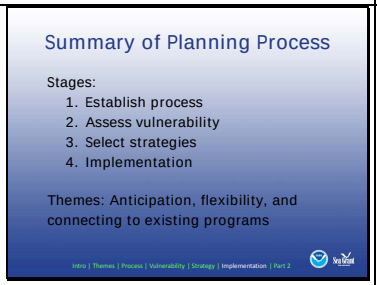
		determined by the vulnerability assessment. These can be grouped if they (a) result from similar climate change impacts (such as effects caused by heavier precipitation) or (b) relate to the same municipal departments (for example, water management may be related to both flood and drought). 14) Brainstorm 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.
Slide 38		This example concerns a 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. 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.

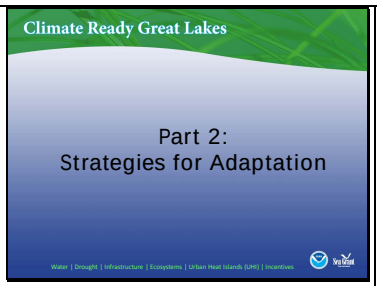
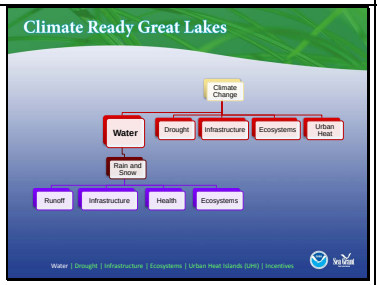
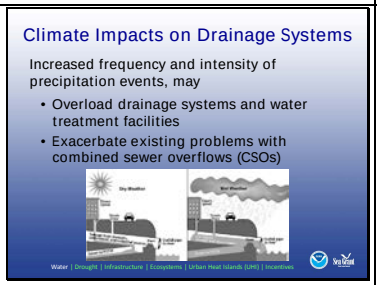
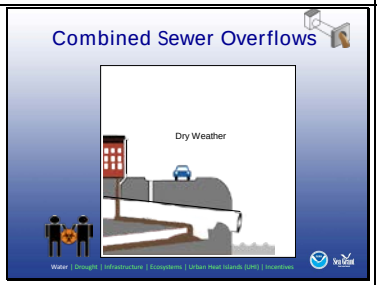
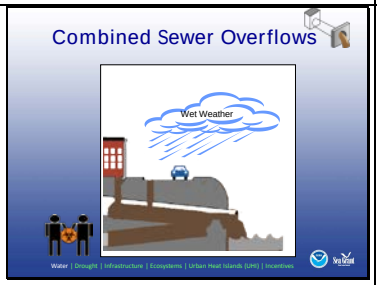
		Connecting to an existing planning processes allowed for the use of existing staff. Note that two part-time workers can be assigned to manage a planning process if it is not possible to have one person be full time, and that paid and unpaid interns can also be useful. For additional resources, consider 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.
Slide 39		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.
Slide 40		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 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. 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.

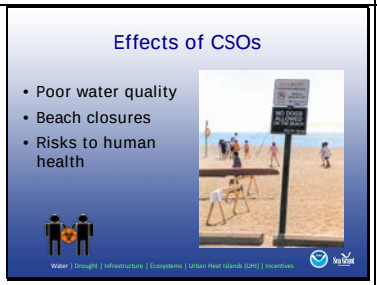
Slide 41		Economic analysis of control options: • Reduce phosphorus in municipal water through technology at treatment plant = $165/lb • Control phosphorus releases upstream = $9.64/lb • Remove suspended solids at treatment plant = $4.61/lb • Prevent suspended solids entering stream at outlet to watershed= $.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 changing 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.
Slide 42		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.*

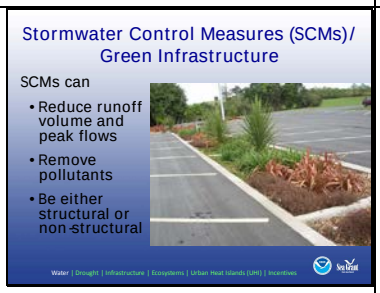
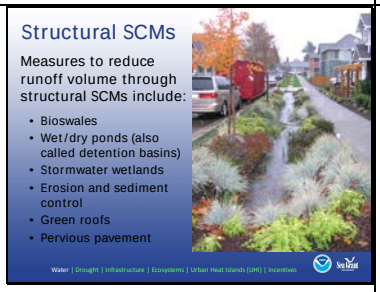
Slide 43		An implementation plan describes what the goals are, who has responsibility for achieving which goals, timing and benchmarks for achieving the goals, and what resources are going to be used to accomplish the goals. These can be determined by asking the following questions: • What is the desired 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.
Slide 44		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.

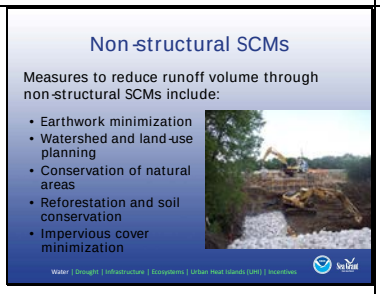
Slide 45		Here is an example of a system for keeping the public up to date on benchmarks. The City of Berkeley created a sustainability plan and developed a website called “See-it” to inform people about the plan. The inner circle shows themes like transportation and land use, the middle ring of the circle 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. **NOTE: Berkeley, CA has updated their climate plan web materials and now uses pdf reports to describe progress toward meeting sustainability goals. Although, the “See-It” website is no longer there, it is still a good example of how interactive, easily navigated communication tools can be formatted into a tool that facilitates public outreach.**
Slide 46		Here, for example, is the See-it page (now in pdf report forms) 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. 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.

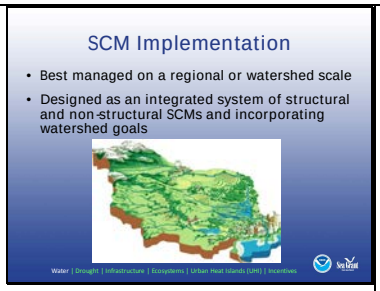
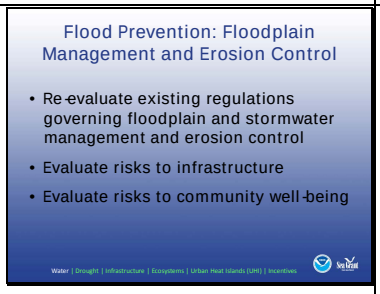
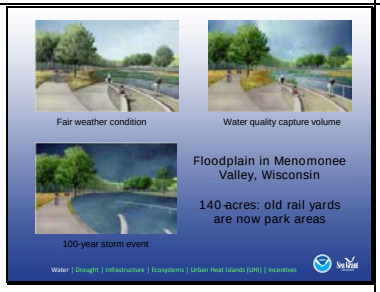
		Tree planting programs have proven particularly successful for cities. Citizens like trees and it is easy to show that benchmarks are being met since there is clearly visible evidence of progress.
Slide 47		Climate adaptation plans require regular re-evaluation and updating. This is true for all municipal 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 will pay off. It helps 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. 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.
Slide 48		

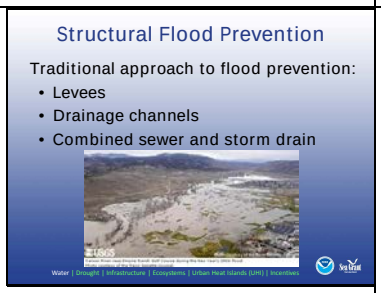
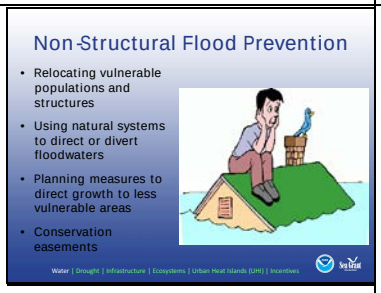
Slide 49		
Slide 50		Climate Change adaptation strategies are broken out here into water, drought, infrastructure, ecosystems, urban heat, and incentives. Let's first look at strategies for water. Climate change will increase the number of extreme weather events. Rain and melting snow increase runoff and affect infrastructure, health, and ecosystems. Management strategies aim to prevent harm to life and property.
Slide 51		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. Figure credit: EPA
Slide 52		
Slide 53		

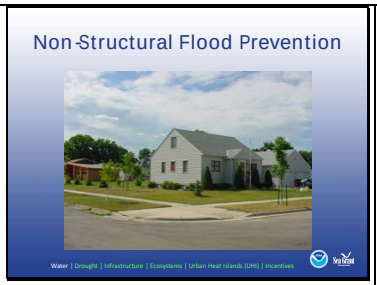
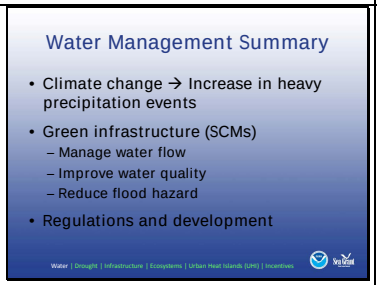
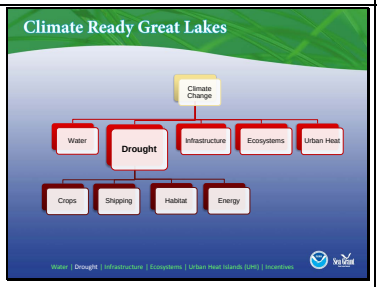
Slide 54		When over a billion gallons of sewage is released into our rivers and lakes from CSOs during heavy rains, water quality diminishes and beaches are closed. CSOs can also negatively affect human health, since waterborne diseases in drinking water can be more prevalent after heavy storm events. 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.
Slide 55		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.

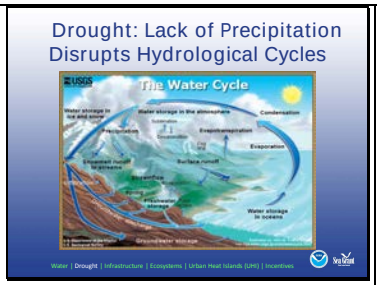
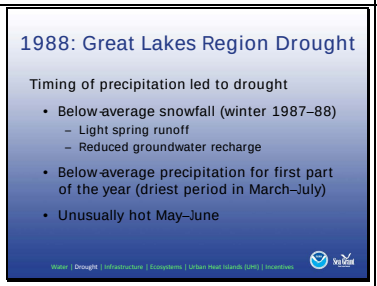
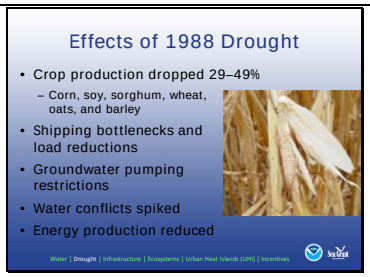
		Finally, one of the least expensive options for dealing with CSOs is to reduce the amount of stormwater runoff created in the first place by using stormwater control measures.
Slide 56		Stormwater Control Measures (also known as Green Infrastructure) attempt to mimic natural hydrology to manage stormwater 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 (conservation on natural areas). Picture source: http://www.landcareresearch.co.nz/research/built/liudd/casestudies/case_manukau.asp
Slide 57		**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.

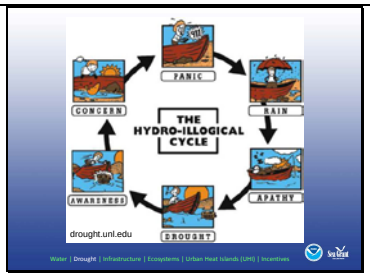
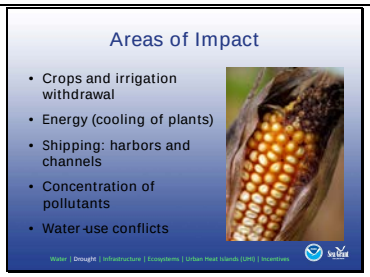
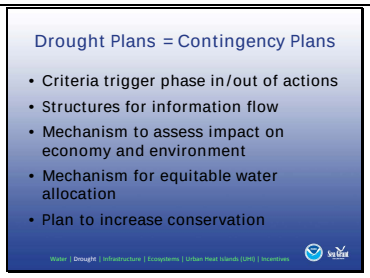
		• **Pervious pavement**: a special type of concrete with a high porosity that allows water from precipitation events to pass through the pavement. Source: NRC Stormwater Report Picture source: http://www.lakecountyil.gov/Stormwater/LakeCountyWatersheds/BMPs/Bioswale.htm
Slide 58		Another way of dealing 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: NRC Stormwater Report Photo source: http://www.mwvetcon.com/4.html

Slide 59		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: NRC Stormwater Report, Summary Picture source: http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1187635073613&lang=eng
Slide 60		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.
Slide 61		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

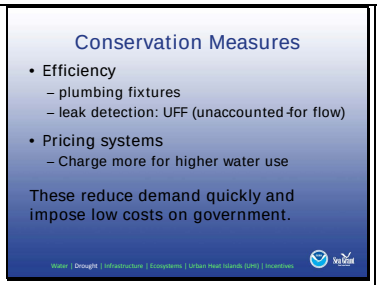
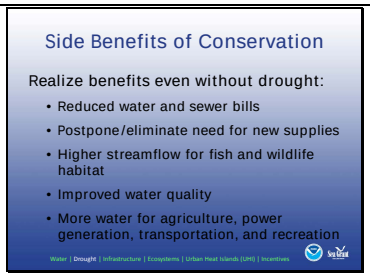
		subsurface system for treatment in park areas. This park area also prevents development in a floodplain and reduces the potential costs of damage during 100-year storm events.
Slide 62		Structural flood prevention is still important. However, regulations may need to be adjusted (such as larger pipe diameters or different configurations of drainage channels). These changes can be incorporated into regularly scheduled maintenance. Picture source: nevada.usgs.gov
Slide 63		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. Wetlands have many important functions including floodplain management. The technical literature on the subject of wetlands management plans developed by the U.S. Army Corps of Engineers and others is quite large, and there are a number of examples of Comprehensive Wetlands Management Plans (CWMPs) available online. Source: APA. *Planning for a New Climate and Energy Future*. pp 69. Picture source: http://www.themoneyalert.com/WhentheWaterRisesArticle.html

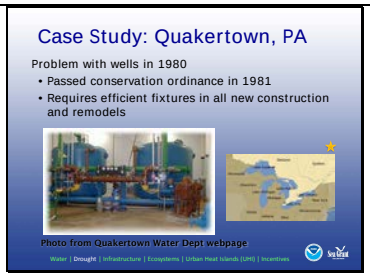
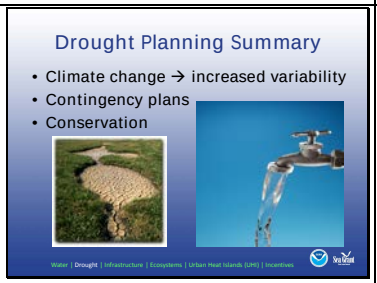
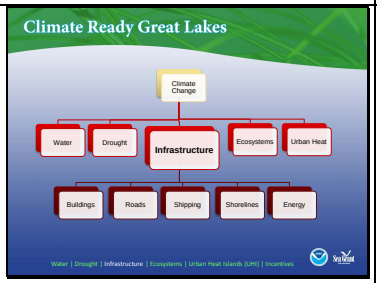
Slide 64		Non-structural flood prevention has gained popularity in regions that have experienced frequent flooding. Often there are FEMA funds that can help with relocation after a major event. For example, flooding has been a frequent problem in Austin, Minnesota, on the banks of the Cedar River. In 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.)
Slide 65		
Slide 66		Droughts are: • Unpredictable. Consider the 1988 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. • A normal part of North American climate patterns. However, climate change is predicted to make them more frequent in the Great Lakes region.

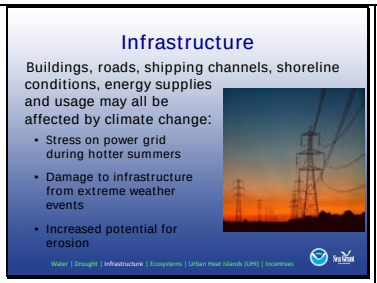
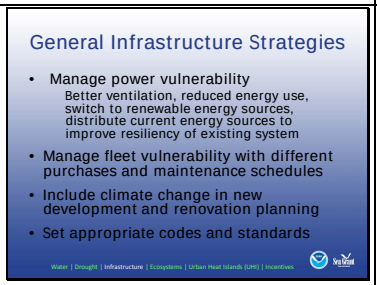
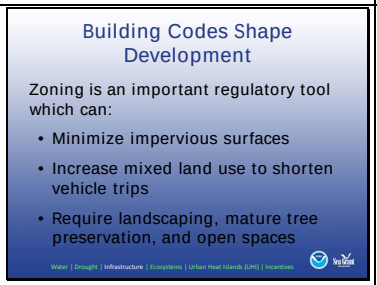
Slide 67		Hydrological cycles normally move water from lakes, oceans, and other bodies of water to the atmosphere by means of evaporation. Water also moves to the atmosphere out of soil and plants through evapotranspiration. Water is then returned to the earth through precipitation (rain and snow). Some 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*.
Slide 68		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*.
Slide 69		• 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

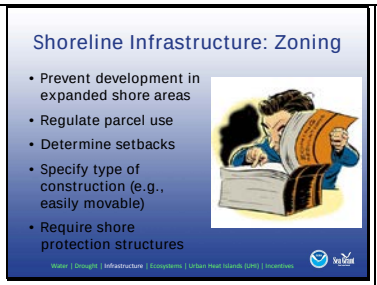
		not able to draw in enough water. Ontario hydroelectric production was reduced by low water levels just as high heat increased demand. Photo source: http://drought.unl.edu/gallery/2003/Missouri/droughtcorn.htm
Slide 70		The greatest barrier to drought planning is human nature—but planning ahead is the 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.
Slide 71		• Crops will 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.
Slide 72		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.
Slide 73		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).
Slide 74		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 (reduced 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.

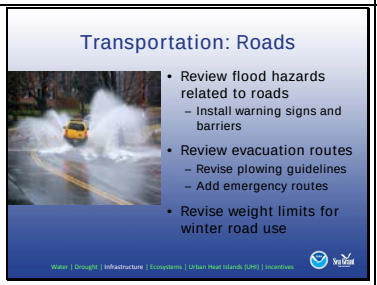
Slide 75		Conservation is the least costly and easiest drought mitigation measure. This can be a first level of response. Leaks or "unaccounted-for flow" (UFF) can cause significant water waste, especially in cities like Chicago that have century-old infrastructure. Illinois now requires municipalities 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.
Slide 76		Poster source: www.nelsonmandelabay.gov.za
Slide 77		Conservation also raises community awareness of water issues, so that people are more likely to respond to other measures if conditions get worse.

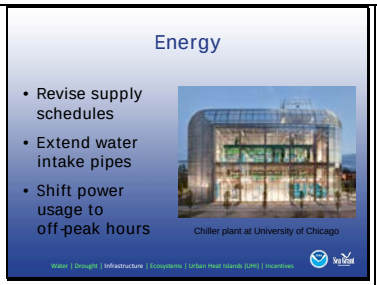
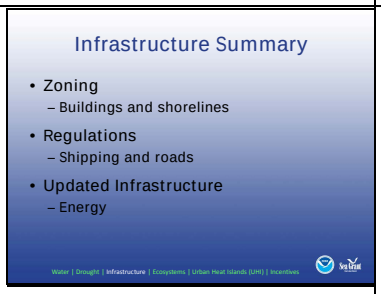
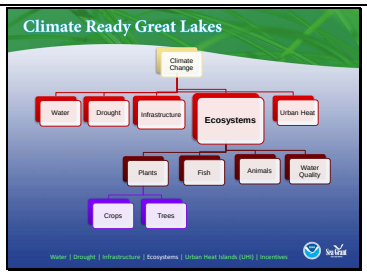
Slide 78		Quakertown, Pennsylvania, relies on wells for its municipal water supply. However, in 1980, the water table was low and the wells were not producing enough water to meet demands. The city developed a conservation ordinance with support from the Pennsylvania Department of Environmental Resources. 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
Slide 79		Photo sources: http://www.greenzer.com/blog/tag/charity-water http://www.emd.wa.gov/preparedness/prep_infocus_summerhaz_schoolprep2009.shtml
Slide 80		All of these areas of infrastructure will be affected by climate change, but there are ways to prepare.

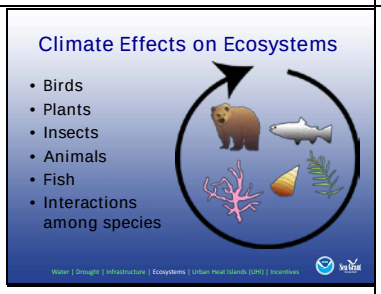
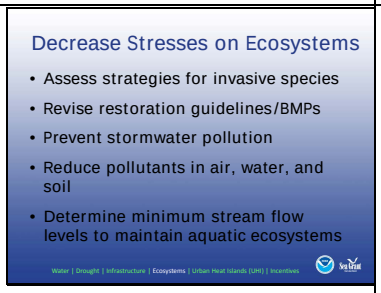
Slide 81		Buildings, roads, shipping channels, shoreline conditions, and energy supplies and usage may all be affected by climate change. Examples of infrastructure impacts include: • Stress on the power grid due to more summer heat waves • Increased annual energy costs due to probable need for additional 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
Slide 82		Source: Chicago Climate Action Plan.
Slide 83		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.

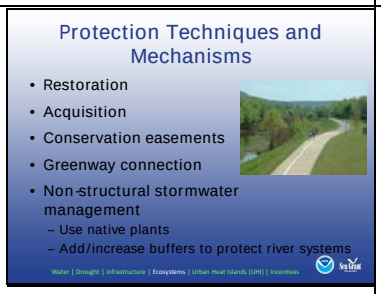
Slide 84		Lower lake levels may increase shore area. Policies for protecting these areas from development should be established beforehand, because preventing development will reduce costs if lake levels fluctuate. Picture source: http://uhelgato.com/2010/06/zoning-in-on-zoning-laws/
Slide 85		Note that 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, Planning Guide
Slide 86		If water levels drop, loading/unloading polices may need to be adjusted to require shallower draft boats in ports. Draft depths will need to be monitored to determine when warnings should be sent to shipping companies. Remember the coal ship that ran aground on a sand bar in Lake Michigan a few years ago? 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
Slide 87		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

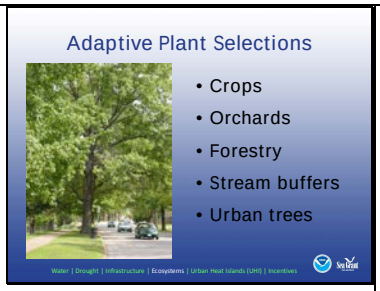
		marine resources that attract the boaters to the water, so they strengthen the basis for this important element of the local economy. **Clean Marina Program** As participants in the Michigan Clean Marina Program, marinas voluntarily pledge to maintain and improve Michigan's waterways by reducing or eliminating 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.

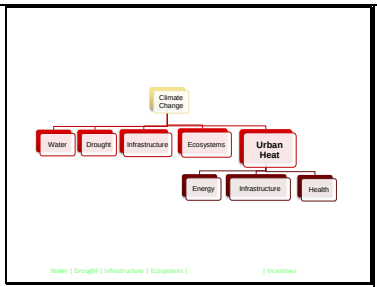
Slide 88		Shore protection structures include walls and jetties that keep sediment in place. Photo source: http://www.merchantcircle.com/blogs/Shoreline.Design.LLC.410-956-4662/2008/5/Living-Shorelines/85824
Slide 89		Beach nourishment makes the beach higher and wider, in order to provide a buffer against 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. (NOAA, Planning Guide) Michigan uses “a permit program that regulates earthmoving, vegetation removal, and construction activities within legally defined critical dune areas.”
Slide 90		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, Planning Guide) Photo source: http://seacoastdocks.com/dredging.html
Slide 91		• 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.

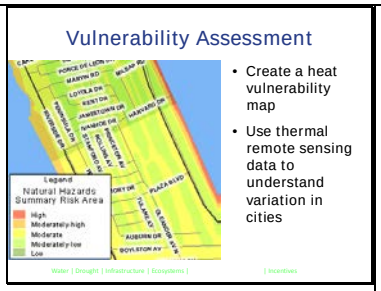
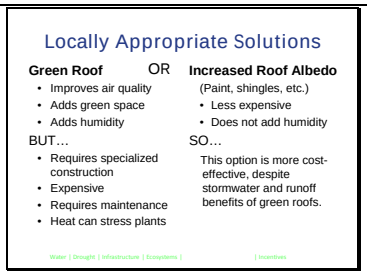
Slide 92		• Plants may have to adjust shipping schedules, because shallower draft means lighter loads of fuel arriving at power plants by ship. • If lake levels drop, extending water intake pipes can help maintain cooling. • Shifting power usage can redistribute energy loads. For example, shift large 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 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.
Slide 93		
Slide 94		Climate change is increasing stresses on ecosystems. Reducing other causes of stress promotes resilience.

Slide 95		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
Slide 96		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
Slide 97		
Slide 98		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? • 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.

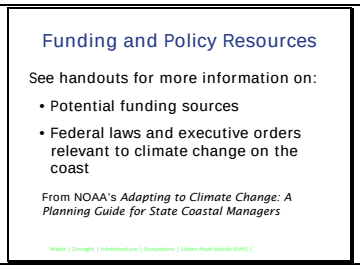
Slide 99		Larger landscapes and waterscapes for biodiversity with internal redundancy and connectivity. Preserve designs need to be able to withstand disruptions in species dispersal and shifting microenvironments. Consider most/least harm to ecosystem when planning for future development.
Slide 100		• 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. Photo source: http://www.hsvcity.com/gis/greenways/aldridge.htm
Slide 101		• 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 streams, which reduces stress on aquatic ecosystems.

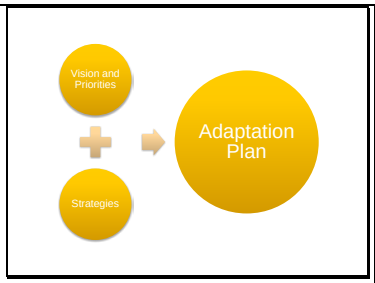
Slide 102		Adaptation planning includes making appropriate plant selections. • **Crops:** Farmers may need to choose varieties of seed that fit new climate patterns. • **Trees:** Trees can't quickly be exchanged for new varieties, so advance planning is important. This is another example of anticipation 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.
Slide 103		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. Photo source: http://flooksolutions.com/id4.html

Slide 104		
Slide 105		
Slide 106	**Urban Heat Islands (UHI)** • Thermal energy from impermeable surfaces causes higher temperatures in dense urban areas. • Hot days can raise city temperatures 4–10°F. • UHI could increase energy demands, roadwear, fires, power outages, city services, respiratory problems, and heat stroke.	
Slide 107	**Vulnerability Planning** Extreme heat events are the #1 cause of weather-related deaths in United States. Communities can reduce vulnerability: • React to heat: emergency plans • Mitigate heat: reduce dark surfaces	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.

Slide 108		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.
Slide 109		
Slide 110		This picture of a park area along Lake Shore Drive in Chicago shows a tree barrier. • 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 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
Slide 111		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.

Slide 112	Summary of Urban Heat Emergency planning: • Cooling centers • Transit to pools Reduce dark surfaces: • Lighten roofs • Increase green space Water | Drought | Infrastructure | Ecosystems | | Incentives	
Slide 113	**Financial and Regulatory Incentives** Use of Policies and Regulations to Promote Adaptation Water | Drought | Infrastructure | Ecosystems | Urban Heat Islands (UHI) |	This section provides an overview of resources that can help with implementation of adaptation measures
Slide 114	Financing Approaches • Most existing financing approaches for adaptation are reactive. • A more effective approach would be having an adaptation financing structure built-in to local policies.  Water | Drought | Infrastructure | Ecosystems | Urban Heat Islands (UHI) |	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
Slide 115	 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 Water | Drought | Infrastructure | Ecosystems | Urban Heat Islands (UHI) |	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 developing 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
Slide 116		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.
Slide 117		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
Slide 118		

Slide 119		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. Samples 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.

(This Page Intentionally Left Blank)

CLIMATE READY GREAT LAKES: MODULE 3 – CLIMATE CHANGE ADAPTATION TOOLS

SCOPE

This module introduces tools that have been developed by NOAA, Sea Grant, and others to assist local communities with assessing climate change vulnerability, as well as planning to adapt to predicted climate change impacts. The module was designed to assist decision makers in selecting the tools most appropriate for their community, and it provides guidance for them to acquire and implement the tools they select.

GOALS

1. Participants will know what tools and resources are available for climate adaptation planning.
2. Participants will have some ability to select appropriate adaptation tools and use them effectively.

OBJECTIVES

By the end of the training:

1. Participants will be aware of a variety of tools and resources available for climate adaptation planning.
2. Participants will know how to access tools and resources for adaptation planning.
3. Participants will demonstrate ability to select a tool that fits their goal and a specific climate impact.

MODULE 3: OUTLINE

Part I: Introduction to Tool Use and Selection

1. What is a tool?
2. Why use tools for adaptation planning?
3. Choosing a Tool
4. Using tools effectively

Part II: Survey of Available Tools

1. Community Outreach Tools
    a. Building Coast-Smart Communities: A Role Play
    b. Additional Community Outreach Tools
2. Education, Training, and Support Tools
    a. NOAA Coastal Services Center (CSC) Trainings
    b. Ecosystem-Based Management (EBM) Tools Network
    c. Additional Education, Training, and Support Tools
3. Data Websites
    a. Great Lakes Information Network
    b. Additional Data Websites
4. Analysis Tools and Systems
    a. Habitat Priority Planner (HPP)
    b. BASINS (Better Assessment Science Integrating point & Non-point Sources)
    c. Additional Analysis Tools and Systems
5. Other Informational Websites
    a. NOAA Climate Services Portal
    b. Additional Informational Websites
6. Visualization Tools
    a. CanVis
    b. Tool Demonstration
7. Worksheet: How Do I Choose the Right Tool?

WORKSHEET: HOW DO I CHOOSE THE RIGHT TOOL?

1. Identify Your Goal

Define the goal/objective that you are trying to achieve. Below, write an adaptation goal that is relevant to your specific locality.

Goal:

How does this relate to other adaptation efforts in your city?

Relation to other adaptation efforts:

2. Look at the Handout *Adaptation Tools Matrix*.

The accompanying *Adaptation Tools Matrix* table is a one-shot glance of the tools selected by Module 3 reviewers as appropriate for Great Lakes climate change adaptation planning. The tools were categorized (community outreach, data, etc.) to help users understand where each 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, called Tool Applications. An 'X' is placed in each box where the reviewers found usefulness of the tool in helping with that particular climate change impact.

Identify one or more of the "Tool Applications" listed along the top of the Adaptation Tools Matrix that you think are most relevant for your own adaptation efforts. List them in the first column below. Then in the second column, write down a few of the Tools that can assist with those applications, keeping in mind which tool categories (community outreach, data, etc) are most relevant for your adaptation planning process.

Climate Impact / Tool Application	Tool Name

3. Narrowing Your Focus: Learn More About Possible Tools

What other resources will you need to use the possible tools you identified in Part 2? Once a tool is identified as a possible candidate for use, the handout ***Climate Adaptation Tools*** is a resource for learning more about each tool. The handout includes information on cost, training and time requirements as well as where to go for more information. Choose one or more of the tools that interested you in the previous step, and look them up in the *Climate Adaptation Tools* handout. Then complete the table below.

Tool Name	Staff Requirements	Technical Requirements	Other Requirements

4. Choose Your Tool, Repeat the Selection Process, or Get Help from a Climatologist

If the steps above helped you to identify an appropriate tool, then you are on your way to developing your Adaptation Plan! However, after researching tools, sometimes 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 accompanying handout entitled ***Handout: Climate Adaptation Tools***. These individuals are a valuable resource to find more information on the latest and upcoming tools.

Climate Ready Great Lakes: Adaptation Tools Matrix

CATEGORY OF TOOL	TOOL NAME	TOOL APPLICATIONS									
		Stormwater Management	Flood Hazard Reduction	Drought	Building/City Infrastructure	Human Health	Shoreline Infrastructure	Transportation	Energy	Air and Water Quality	Ecosystem Resiliance
Community Outreach	Building Coast-Smart Communities: A Role Play Exercise	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 & Support	Climate Adaptation Knowledge Exchange (CAKE)	X	X	X	X	X	X	X	X	X	X
Education, Training & Support	Climate Change in the Great Lakes Region: Starting a Public Discussion	X	X	X	X	X	X	X	X	X	X
Education, Training & Support	Digital Coast Coastal Inundation Toolkit	X	X		X		X				X
Education, Training & Support	Coastal Services Center Training	X	X	X	X	X	X	X	X	X	X
Education, Training & Support	Ecosystem Based Management Tools (EBM)	X	X	X	X	X	X	X	X	X	X
Education, Training & Support	Great Lakes Weather and Climate	X	X	X							
Education, Training & Support	National Estuarine Research Reserve (NERR) Training	X	X	X	X	X	X			X	X
Education, Training & Support	Sea Grant Training: Ohio State University Webinars	X	X	X	X	X	X	X	X	X	X
Data	Coastal Change Analysis Program Regional Land Cover				X					X	X
Data	Coastal County Snapshots		X								
Data	Great Lakes Information Network (GLIN): Maps and GIS	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	Climate Ready Water Utilities (CRWU)	X	X	X	X					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	
Analysis	NatureServe Vista				X			X	X		X
Analysis	Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT)	X	X							X	X
Analysis	Roadmap for Adapting to Coastal Risk	X	X		X	X				X	
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	X	X
Informational	NOAA Coastal Service How-to-Guides	X	X	X	X	X	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

HANDOUT: CLIMATE ADAPTATION TOOLS

Updated July 2012

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

- **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: Starting a Public Discussion**
  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

- **Digital Coast 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
  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 Culver, at Mary.Culver@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 Tools (EBM)**
  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

- **National Estuarine Research Reserve (NERR) Training**
  http://www.nerrs.noaa.gov/Training.aspx
  The National Estuarine Research Reserve Training System offers 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 is customized for the Great Lakes region. Training has been provided at a number of different locations, and trainings can be coordinated through Old Woman Creek NERR 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

- **Sea Grant Training: Ohio State University Webinars**
  http://changingclimate.osu.edu/webinars/
  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
  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

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
  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; Users can provide feedback at: http://www.epa.gov/myenv/feedback.htm
  Keywords: Health; Hazards
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **New York Ocean and Great Lakes Data Portal**
  http://portalnyoglecc.stone-env.com/geoportal/catalog/main/home.page
  This link leads users to the New York Ocean and Great Data Portal, where users can easily access an extensive catalogue of data, ranging from social to economic to environmental information. The Data Portal has been created by the New York Ocean and Great Lakes Ecosystem Conservation Council (Council) to help the public easily access information provided in the Atlas Data Viewer. The Data Portal allows visitors, from the general public to technical specialists and professionals, to search for and find available data by entering keywords into a search box.
  Contact: Users can ask questions or leave feedback at: http://portalnyoglecc.stone-env.com/geoportal/catalog/identity/feedback.page
  Keywords: Data viewer; Coastal management
  Cost: Free
  Training/Time Requirements: None

- **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
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://oceanservice.noaa.gov/dataexplorer/
  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: Users may submit questions or comments at: http://nosdataexplorer.noaa.gov/NOSDataExplorer/catalog/identity/feedback.page
  Keywords: Coastal data; Database
  Cost: None
  Training/Time Requirements: None
  Other Requirements/Notes: None

- **Ohio Coastal Atlas and GIS**
  http://ohiodnr.com/tabid/23320/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 (BASINS)**
  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.

- **Climate Ready Water Utilities (CRWU)**
  http://water.epa.gov/infrastructure/watersecurity/climate/index.cfm
  The U.S. Environmental Protection Agency (EPA) has developed its Climate Ready Water Utilities (CRWU) initiative to assist water and wastewater utilities in becoming "climate ready." Through the development of tools and other resources, CRWU supports the implementation of plans and adaptation strategies at water and wastewater utilities that account for potential climate change impacts and build water sector resilience. The Climate Resilience Evaluation and Awareness Tool (CREAT) is an interactive tool designed for water and wastewater utilities to assess the risk of potential climate change impacts on their assets, operations, and missions and to develop adaptation plans, using a flexible, systematic assessment process.
  Contact: For more information: crwuhelp@epa.gov
  Keywords: Water resources; Water management
  Cost: None
  Training/Time Requirements: Time to search website / learn about tools. For the Climate Resilience Evaluation and Awareness Tool (CREAT), free video trainings are available in Flash format.
  Other Requirements/Notes: None

- **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.gov, Telephone: (202) 646-3427
Vince Brown, HAZUS User Groups (HUGs), Private Sector:
Vincent.Brown@dhs.gov Telephone: (202) 646-2725
Phillip Moore, Emergency Management Institute and Training:
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.

- **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

- **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: David Eslinger, Dave.Eslinger@noaa.gov
  Or Users can find a question form at: http://www.csc.noaa.gov/digitalcoast/feedback
  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.

- **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: vista@natureserve.org
  Or, 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 Eslinger, David.Eslinger@noaa.gov

For support, send an email to: digital.coast@noaa.gov
Users can ask a question at: http://www.csc.noaa.gov/digitalcoast/feedback
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/digitalcoast/training/roadmap/
  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
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.
  Contact: Email: 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**
  http://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: Beth Hall, bethhall@illinois.edu
  Website: http://mrcc.isws.illinois.edu/

  - **Michigan**
    Michigan State Climatology Office
    Contact: Jeffrey Andresen, andresen@msu.edu
    Website: http://climate.geo.msu.edu/

  - **Ohio**
    Ohio State Climatology Office
    Contact: Jeffery Rogers, 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

- **Minnesota**
  Minnesota State Climatology Office
  Contact: Greg Spoden or Pete Boulay, climate@umn.edu
  Website: http://climate.umn.edu/

- **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/

Workshop Evaluation: Climate Ready Great Lakes

Module 3: Climate Adaptation Tools

Directions: Please read carefully and respond to the following questions:

1) How much has this presentation improved your awareness of tools and resources available for adaptation planning? (Check one.)

☐ Greatly improved	☐ Somewhat improved	☐ Slightly improved	☐ No change

2) How much has this presentation improved your confidence in your ability to access and select tools and resources for adaptation planning?

☐ Greatly improved	☐ Somewhat improved	☐ Slightly improved	☐ No change

3) Do you plan to use at least one of the tools presented here in your adaptation planning?

☐ I will definitely use	☐ I may use	☐ I won't use

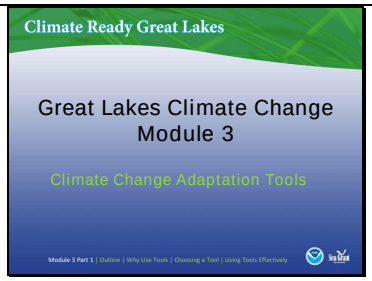
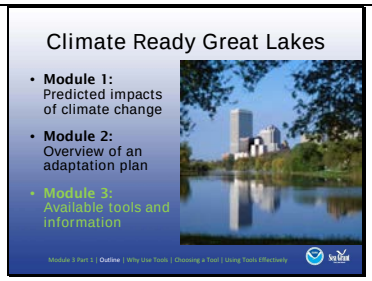
4) Which tool(s) are you most likely to use?

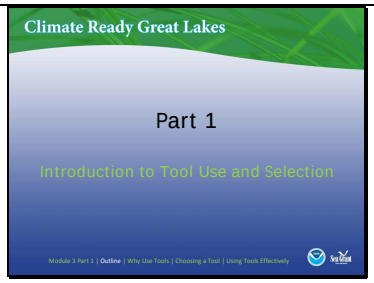
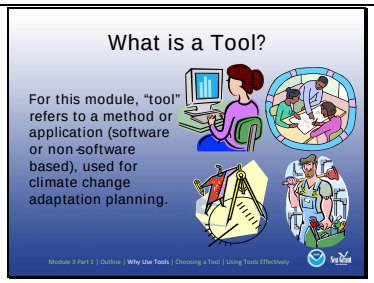
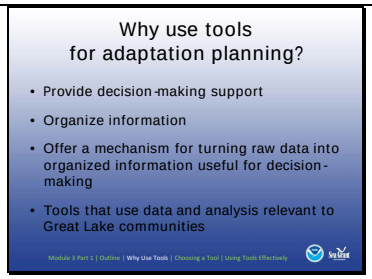
5) Do you plan to look for other tools not presented in this module that would be better suited to meet your adaptation planning needs?

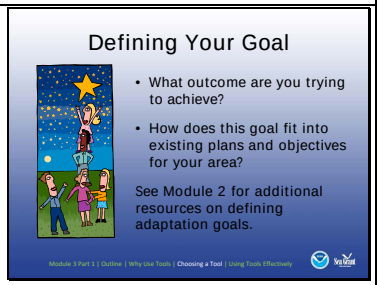
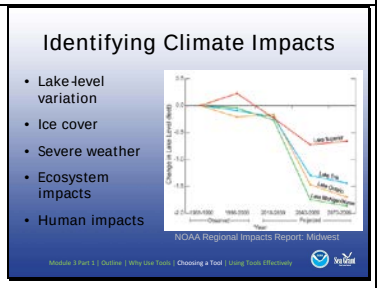
☐ I will definitely look	☐ I may look	☐ I won't look

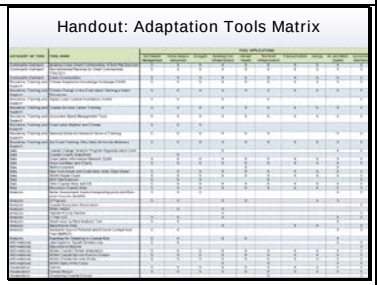
6) What additional types of tools do feel that you need?

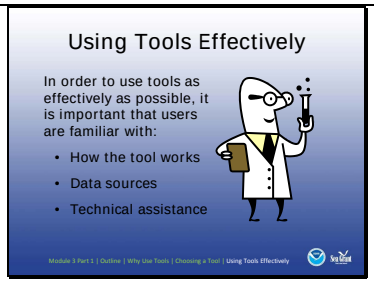
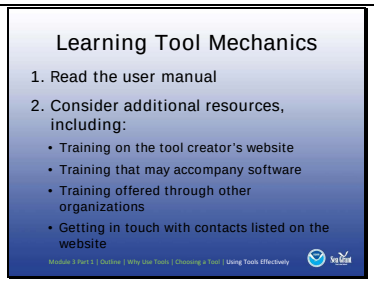
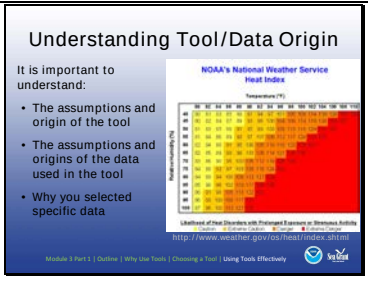
7) Additional comments…

Slide 1		
Slide 2		
Slide 3		Climate Ready Great Lakes is a series of three related—but stand alone—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.
Slide 4		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.

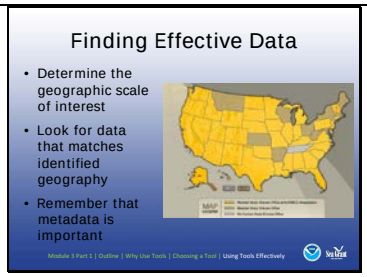
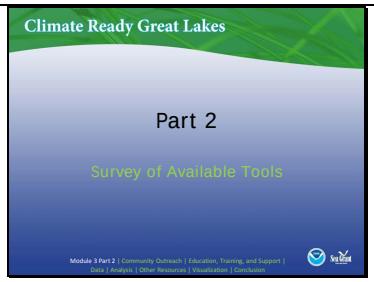
Slide 5		Tools are an important resource for adaptation planning. Part 1 teaches how to select tools appropriate for your needs and how to effectively use tools and related resources.
Slide 6		First, it is important to clarify what we mean by the word "tool." In this module, "tool" can indicate any of 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-computer based. 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."
Slide 7		Tools are important in adaptation planning, because they can • Provide guidance and support for decision maker • Help to organize ideas for planning and to get adaptation plans started • Help turn raw data into organized information useful for decision-making. 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

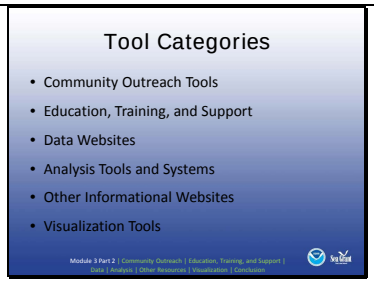
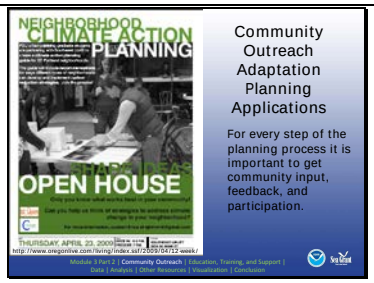
		focuses particularly on tools relevant—and available—to Great Lakes coastal cities. Source citation: National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management. "Adapting to Climate Change: A Planning Guide for State Coastal Managers." http://coastalmanagement.noaa.gov/climate/adaptation.html (accessed December 28, 2010)
Slide 8		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. Consider the following questions when choosing a tool: • What is the goal you are trying to achieve? • Which climate change impacts are you trying to adapt to? • What resources do you have available? For example, personnel, financial assistance, or technical expertise. • How does the project fit into larger planning goals in your community? • Where are help resources (such as expert consultation)?
Slide 9		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.
Slide 10		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

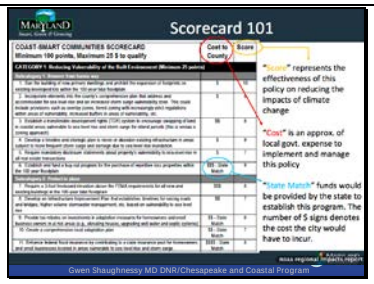
Slide 11		• Learn from what others have done. It is important to review case studies and best practices, when available. Your state climatologist is one resource who may be able to help identify best practices and tools. There will be more information in the "Education, Training, and Support" section 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
Slide 12		Next, refer to the spreadsheet handout **Adaptation Tools Matrix.** (*Have participants look at the handout.*) 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. (*Distribute the handout.*)

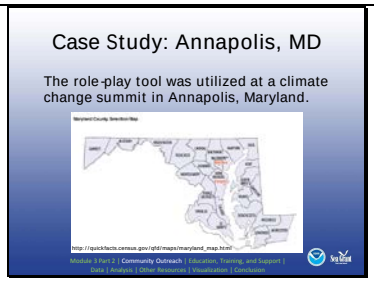
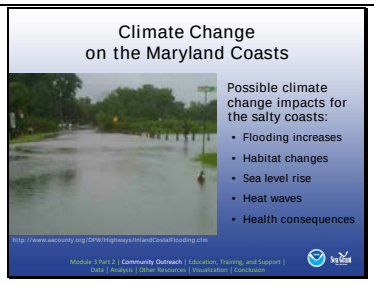
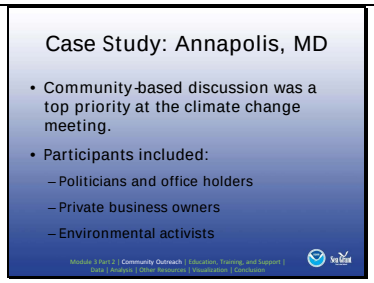
Slide 13		In the tool description handout, the information for each tool includes a link, description, keywords, cost, training/time requirements, and other notes. The training and time requirements indicate formal training and time to learn the tool. Some tools may require tinkering and time to become familiar with the interface. (*Take a moment and go over process of selecting a tool.)*
Slide 14		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: • Knowing the mechanics behind how a tools works • Understanding where data sources exist • Using available resources for technical support/assistance
Slide 15		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.
Slide 16		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

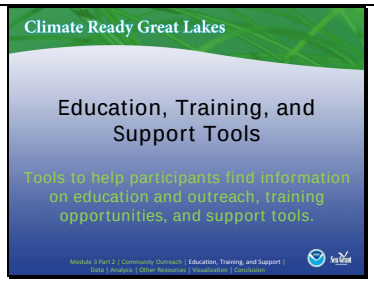
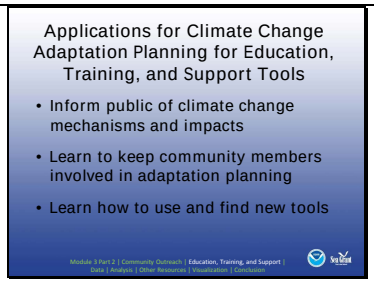
		try to research this information. Similarly, if you're using your own data in the tool, you should be ready to explain to others where the data came from, the date it was produced, and other important details. Image citation: NOAA's National Weather Service, Office of Climate, Water, and Weather services. "Heat: A Major Killer." http://www.weather.gov/os/heat/index.shtml (accessed December 21, 2010)
Slide 17		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 Climate Adaptation Tools handout for a list of state and regional climatologists and their office websites (pages 3-19 and 3-20). 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)

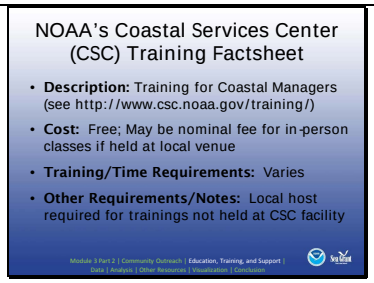
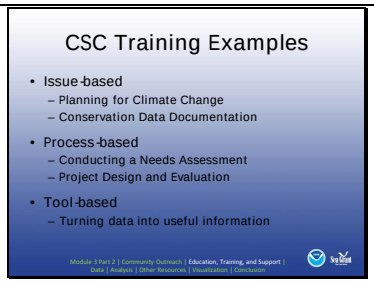
Slide 18		As was mentioned previously, some tools require users to generate their own data. This can range from providing your own data on climate change predictions (for a image creating program) to uploading your own shapefiles (for a GIS platform). If you need to find your own data, first define the 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)
Slide 19		Part 2 of this module focuses on showcasing examples of tools that are available to assist communities in adaptation planning efforts.

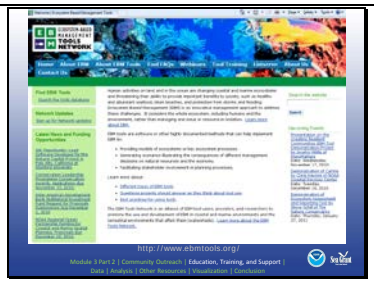
Slide 20		In this module, tools are divided into six main categories based on their structure and the types of services they provide. For each category, we will first explain how the category can be applied to adaptation planning in general, and then give an example of a tool that fits in that category. 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.)
Slide 21		Community Outreach tools can assist decision makers communicate with citizens as well as decision makers in both the public and private sector.
Slide 22		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)
Slide 23		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)

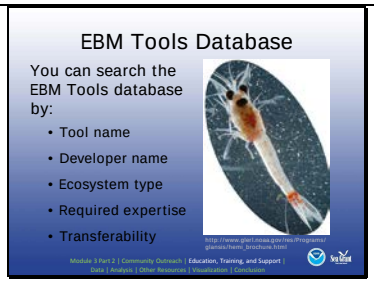
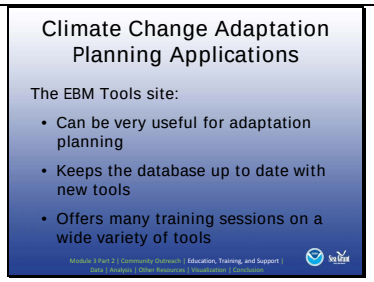
Slide 24		This tool is a half-day, role-play exercise that helps initiate community-based discussions about (1) climate change adaptation options and (2) the challenges associated with climate change (mainly focused on policy). There is no cost for the workshop; however, participants would need to commit to a half-day workshop and extensive advanced workshop preparation may be required. Materials are available free of charge on this website http://maryland.coastsmart.org/?page_id=114.
Slide 25		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.
Slide 26		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.

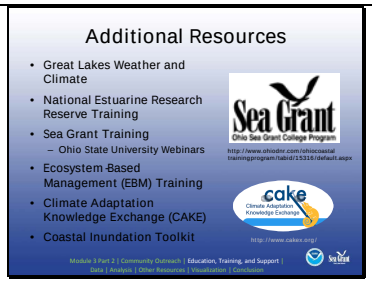
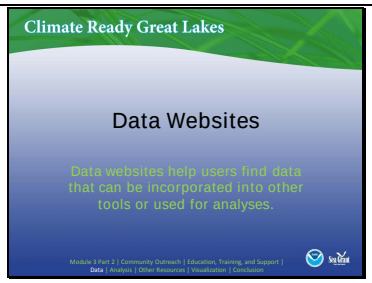
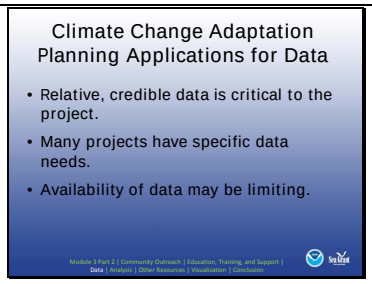
Slide 27		This exercise can be incorporated at various stages of the planning process, but may be best applied at the beginning of the planning process (when the framework is still being established). This exercise can help to encourage participants to become more involved in the climate change adaptation 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 (such as complications from various viewpoints).
Slide 28		In a case study from the Coast Smart website, the role-play exercise was 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)
Slide 29		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)
Slide 30		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

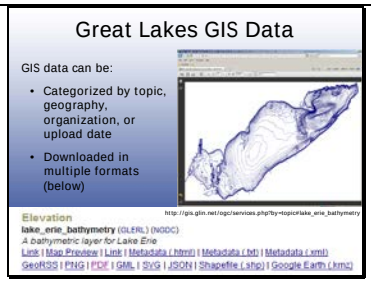
		different stakeholder perspectives related to climate change adaptation. Source citation: Maryland Department of Natural Resources, Consensus Building Institute, MIT-USGS. 2009. "Building Coast-Smart Communities: A Role Play Exercise." http://maryland.coastsmart.org/ (accessed November 15, 2010)
Slide 31		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://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=30004O2Y.PDF (accessed May 2012)
Slide 32		The tools in the education, training, and support category help participants find information on education and outreach tools, training opportunities, and support tools.
Slide 33		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.
Slide 34		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)

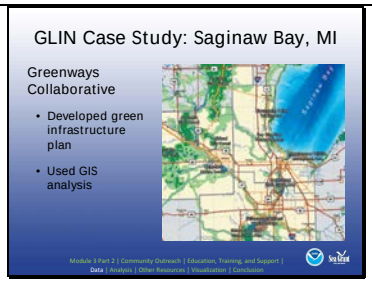
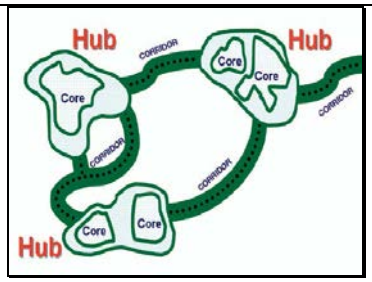
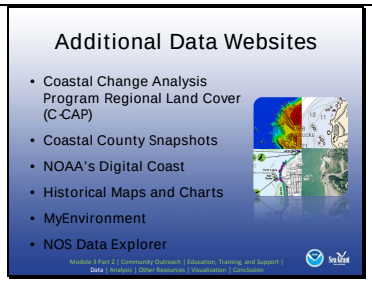
Slide 35		The CSC website directs users to web-based and in-person training resources that address a variety of topics, many of which have applicability to climate change and adaptation planning. The website helps users find a number of online and in-person modules targeted towards coastal managers. 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 a CSC facility.
Slide 36		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 Climate Change" 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)
Slide 37		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, and Community Risk and Vulnerability Assessment tool. CanVis: CanVis is a visualization program used to "see" potential impacts from coastal development or sea level rise. Users can download background pictures and insert the objects (hotel, house, marina, or other objects) of their choosing. The software is used by municipalities to brainstorm new ideas and policies, undertake project planning, and make presentations. Habitat Priority Planner: This tool aids in making decisions about habitat conservation, restoration, and land use planning. The Habitat Priority Planner takes away much of the subjective nature of the process by providing a means of obtaining critical habitat analyses that are consistent, repeatable, and transparent. The program allows users to easily test various ideas and "what if" scenarios on

		the fly, making it the perfect tool to use in a group setting. N-SPECT: Use the Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT) to investigate potential water quality impacts from development, other land uses, and climate change. N-SPECT was designed to be broadly applicable, but the tool operates most accurately in medium-to-large watersheds having moderate topographic relief. C-CAP: The Coastal Change Analysis Program (C-CAP) produces a nationally standardized database of land cover and land change information for the coastal regions of the U.S. C-CAP products provide inventories of coastal intertidal areas, wetlands, and adjacent uplands with the goal of monitoring these habitats by updating the land cover maps every five years. 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)
Slide 38		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.
Slide 39		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)

Slide 40		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.
Slide 41		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)
Slide 42		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)
Slide 43		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.

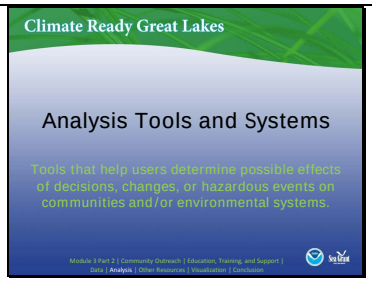
Slide 44		Refer to the handout on additional training tools. Image citations: • Ohio.gov. "Ohio Coastal Training Program." http://www.ohiodnr.com/ohiocoastaltrainingprogram/tabid/15316/default.aspx (accessed December 21, 2010) • Climate Adaptation Knowledge Exchange. "Climate Adaptation Knowledge Exchange (CAKE)." http://www.cakex.org/ (accessed December 21, 2010)
Slide 45		Data websites help users find data that can be incorporated into other tools or used for analyses.
Slide 46		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.)***
Slide 47		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)
Slide 48		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)

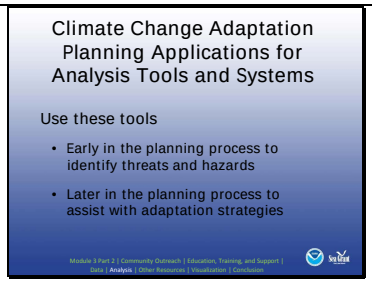
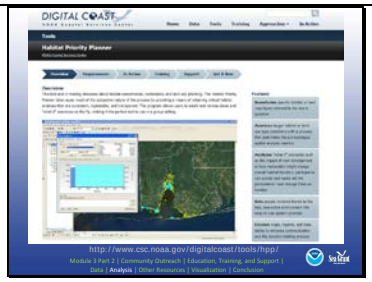
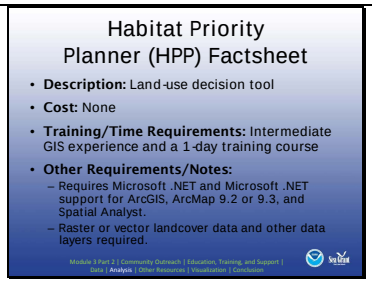
Slide 49		The GLIN website offers GIS data in multiple formats, including shapefiles, PDFs, and PNGs. On the bottom of the slide, you can see the various data formats and metadata that are available with each data layer. This example shows the files that are associated with the lake_erie_bathymetry layer 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)
Slide 50		**NOTE: You may want to try to connect to map explorer. It is not easy and one may have to create a login. Suggest you just discuss the use of the map gallery, next slide.** 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."
Slide 51		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) Image citation: great-lakes.net. "Great Lakes Information Network."
Slide 52		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.

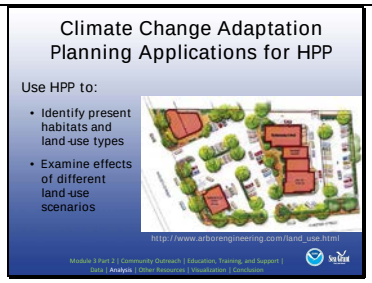
Slide 53		The Saginaw Bay Greenways Collaborative is an example of a case study that used GIS to support a comprehensive green infrastructure plan. This study used GIS to analyze spatial information in order to identify the ecological strengths and weaknesses of an area. GIS suitability models were created 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."
Slide 54		*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."
Slide 55		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: • C-CAP (http://www.csc.noaa.gov/digitalcoast/data/ccapregional/) (accessed May 2012) - The Coastal Change Analysis Program (C-CAP) produces a nationally standardized database of land cover and land change information for the coastal regions of the U.S. C-CAP products provide inventories of coastal intertidal areas, wetlands, and adjacent uplands with the goal of monitoring these habitats by updating the land cover maps every five years. • Coastal County Snapshots (http://www.csc.noaa.gov/digitalcoast/tools/snapshots/) (accessed May 2012) - Coastal County Snapshots turn complex data into easy-to-understand stories, complete with charts and graphs. Users select a coastal county of interest

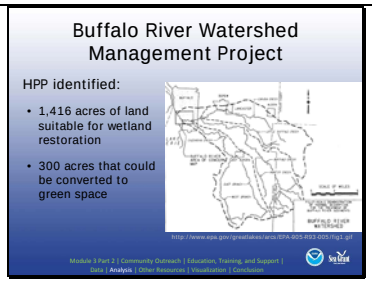
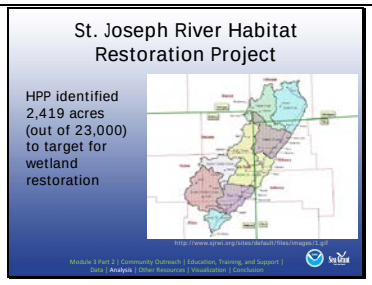
		and the website does the rest, providing information that can help communities become more resilient to coastal hazards. Local officials can use the snapshots as a planning tool to assess their county's resilience to flooding and understand the benefits provided by natural resources. The handouts generated by the snapshots can be a helpful educational tool when working with governing bodies and citizen groups. • NOAA Historical Maps and Charts (http://historicalcharts.noaa.gov/about.html) (accessed May 2012) - Covers the land and waters of the United States of America, including territories and possessions (past and present). The images are free to download, and may be used for commercial or educational purposes. Although not required, we encourage users to cite "NOAA's Historical Map & Chart Collection" when using the image(s). Today's Office of Coast Survey traces its charting efforts back to 1807, when President Thomas Jefferson founded the Survey of the Coast. To celebrate and preserve this long history, NOAA started assembling the collection in 1995 as a data rescue effort. NOAA continues to preserve charts and maps produced by NOAA's Coast Survey and its predecessors, especially the U.S. Coast and Geodetic Survey and the U.S. Lake Survey (previously under the Department of War). The collection also covers many areas that most people may not realize were once a part of early Coast Survey history. As the first federal scientific agency, the U.S. Coast and Geodetic Survey (as the agency was known from 1878 to 1970) produced land sketches, Civil War battle maps, and aeronautical charting from the 1930s to the 1950s. • "My Environment." Environmental Protection Agency. (http://www.epa.gov/myenvironment/) (accessed May 2012) - MyEnvironment provides immediate access to a cross-section of environmental data for any geographical location in the U.S. View maps of EPA and partner data

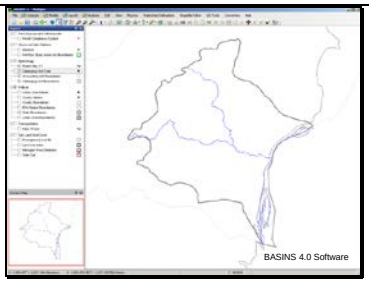
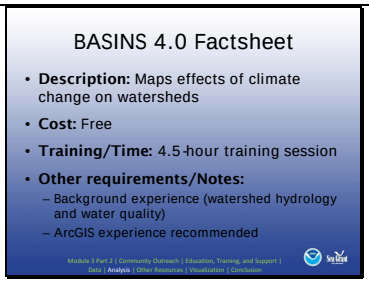
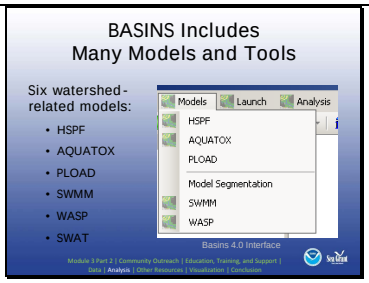
		specific to your area of interest. Information on Air, Water, Land, Community, Health and Energy can be visualized on map, downloaded and printed.
		
		• National Ocean Service. "NOS Data Explorer." (http://oceanservice.noaa.gov/dataexplorer/) (accessed May 2012) - The National Ocean Service (NOS) **Data Explorer Geoportal** application provides centralized access to distributed NOS geospatial data, tools, applications and services. This Web mapping application allows users to search and access geospatial data via the NOS master catalog of FGDC metadata. Examples of key NOS geospatial data available via this site include:
		  • NOAA Nautical Charts, bathymetry, and shoreline data;
		  • Coastal Change and Analysis data (LiDAR and IfSAR data), remotely sensed imagery and aerial photography;
		  • Benthic habitat maps, National Marine Sanctuaries Boundaries and protected areas data;
		  • Environmental Sensitivity Index maps that provide critical information for oil spill responders and other emergency response needs;
		  • Geodetic control benchmarks, coastal and marine observational data including real time tides and currents data for marine navigation and much more.

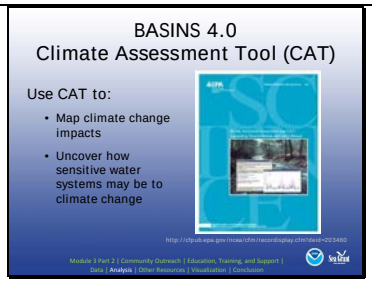
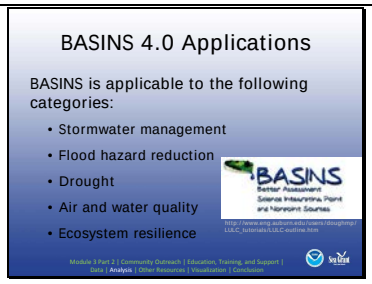
Slide 56		Analysis tools and systems help determine possible effects of decisions, changes, or hazardous events on communities and/or environmental systems.

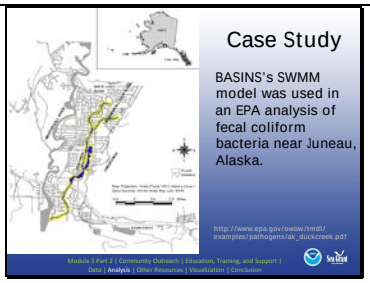
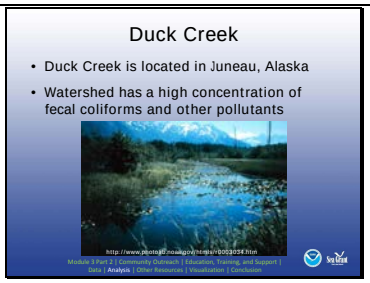
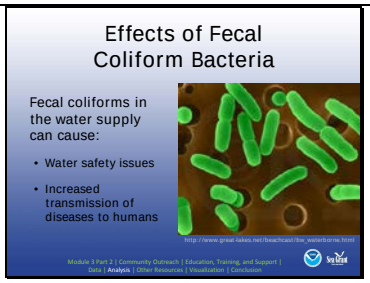
Slide 57		Analysis tools and systems encompass a wide range of tools, which means that tools in this category can be used at different parts of the adaptation planning process. • Some of the tools may be used earlier in the process to identify threats and hazards and assess vulnerabilities and opportunities (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).
Slide 58		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)
Slide 59		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)

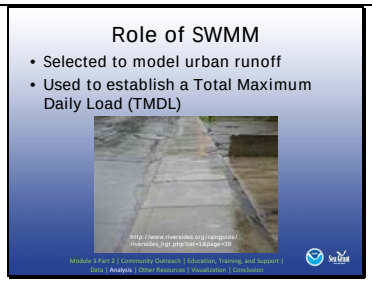
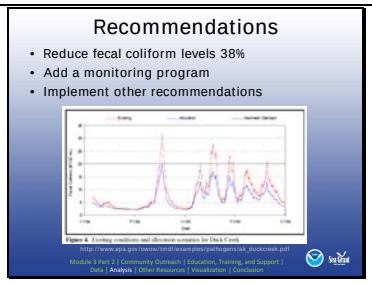
Slide 60		HPP can be used to identify areas that are best-suited for a specific purpose: • You can use this software to examine what may happen to local habitats under various development scenarios. • Additionally, if you give HPP certain conditions and requirements, it can help you find areas that fit 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)
Slide 61		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)
Slide 62		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)

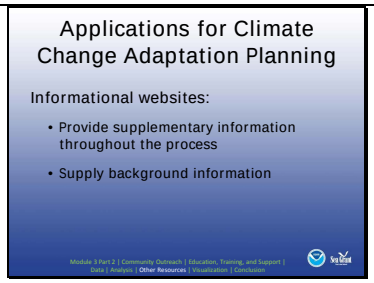
Slide 63		Given the contamination, water quality, and habitat degradation issues facing the Buffalo River watershed, the goals of the project were focused on wetland restoration and pollution reduction from non-point sources. The HPP software was used to identify areas that were suitable for conversion 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)
Slide 64		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)
Slide 65		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)

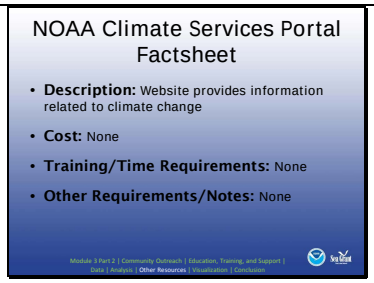
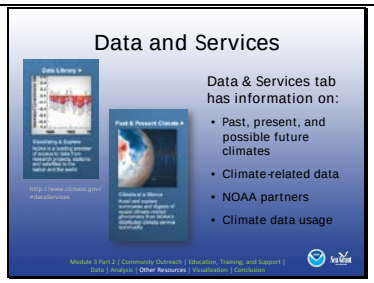
Slide 66		This is a picture of a watershed in Detroit, Michigan, in the BASINS 4.0 software. BASINS is the second analysis system that we would like to showcase, because of its applicability to adaptation planning. Image citation: Environmental Protection Agency. *Better Assessment Science Integrating 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)
Slide 67		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).
Slide 68		BASINS has six watershed-related models available in the software. Each model runs by itself, but is also interlinked with the other models. • HSPF is a watershed model. • AQUATOX is a model that simulates interactions between pollutants and biotic life within an aquatic system. • PLOAD is used to determine the amount of pollutants a watershed is carrying. • SWMM is the Storm Water Management Model, which shows how precipitation and various pollutants can move through and effect stormwater systems. • WASP is a Water Quality Analysis Simulation program, which can be used to model water quality in watersheds. • 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

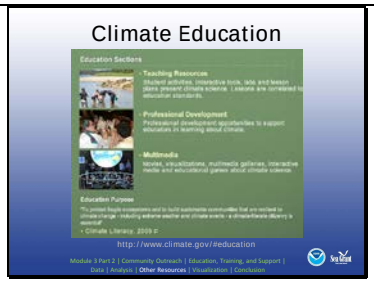
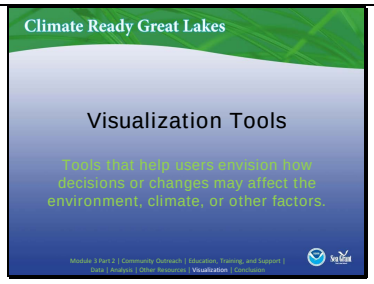
		December 22, 2010) • **PLOAD:** Environmental Protection Agency. 2001. *PLOAD version 3.0 An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects*. http://water.epa.gov/scitech/datait/models/basins/upload/2002_05_10_BASINS_b3docs_PLOAD_v3.pdf • **SWMM:** Environmental 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)
Slide 69		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)
Slide 70		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>.

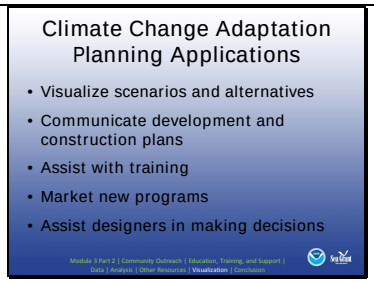
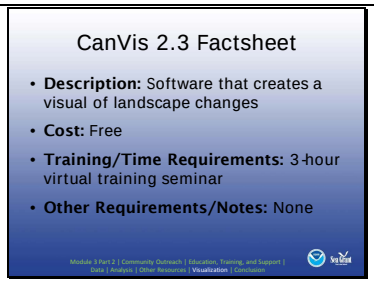
Slide 71		The SWMM model from BASINS 4.0 was used by the EPA in an analysis of fecal coliform bacteria in the Duck Creek watershed near Juneau, Alaska. This case study is just one example of the many climate change adaptation planning applications of the BASINS 4.0 analysis system. Source citation: Environmental 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)
Slide 72		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)
Slide 73		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)

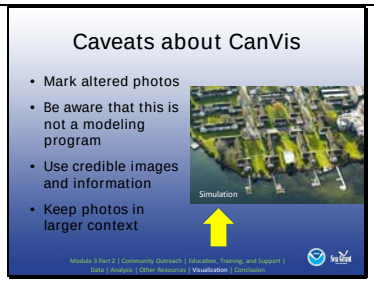
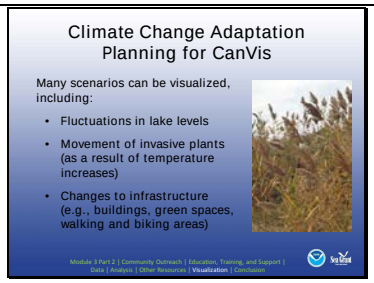
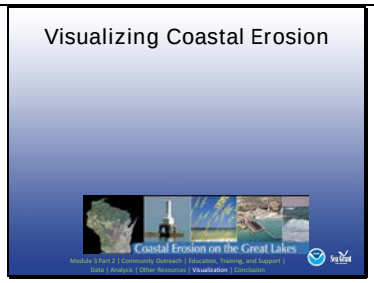
Slide 74		For this case, the EPA selected the SWMM model, because it can be used to (1) simulate urban runoff and (2) show the type and quantity of pollutants that are likely to be carried in the runoff. The SWMM model was used to establish a Total Maximum Daily Load (TMDL) for fecal coliform bacteria 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)
Slide 75		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.

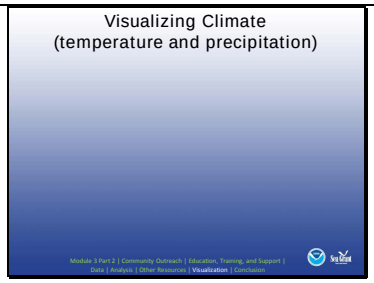
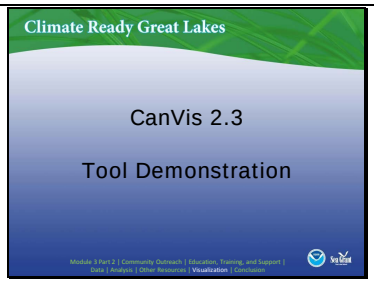
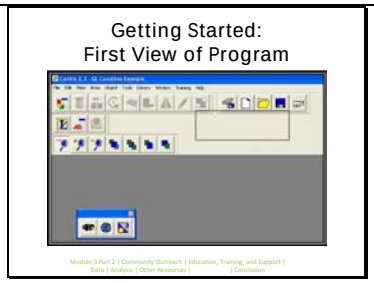
		• Develop a flow allocation to improve fish habitat and water quality. • Create a stormwater management plan. Check out the EPA website (http://water.epa.gov/scitech/datait/models/basins/bsnsdocs.cfm#hspf) for more examples of BASINS applications, including Great Lakes examples. Image citation: Environmental 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)
Slide 76		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)
Slide 77		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.
Slide 78		This group of tools and websites helps 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.
Slide 79		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)

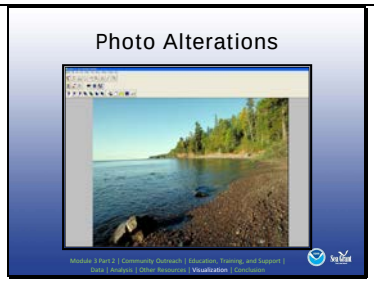
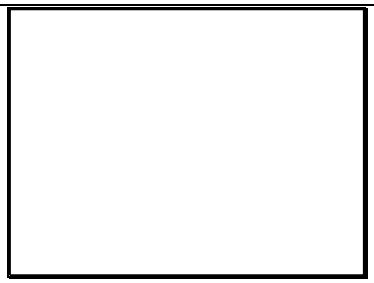
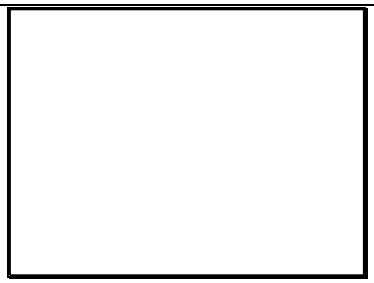
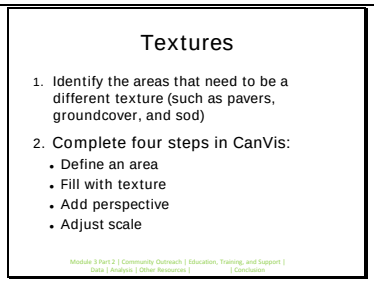
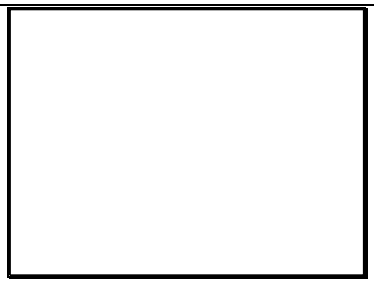
Slide 80		This website offers climate information—ranging from data and services to educational materials and information. It is free to use and does not have any training requirements.
Slide 81		The NOAA Climate Services Portal has four main informational tabs on the website. The first tab is for the ClimateWatch magazine, and users can browse articles, videos, and images related to the magazine. The second tab links 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)
Slide 82		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 climate and 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)

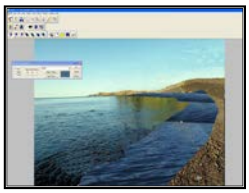
Slide 83		The final tab directs users to valuable educational materials related to climate change. Various resources are available for teachers to use in the classroom, and there is also information on professional development for educators. There is also a resource that provides multimedia educational 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)
Slide 84		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.
Slide 85		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
Slide 86		Visualization tools help users envision how decisions or changes may affect the environment, climate, or other factors.

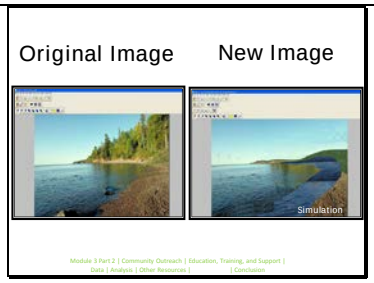
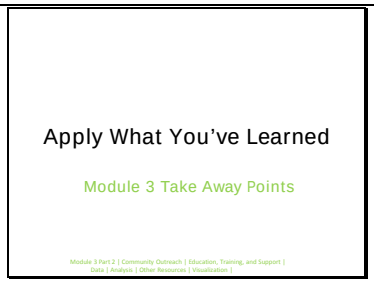
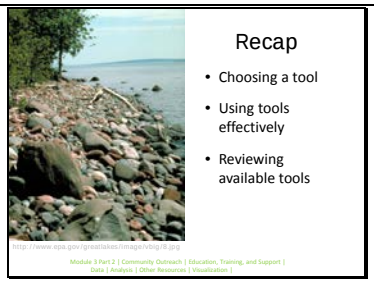
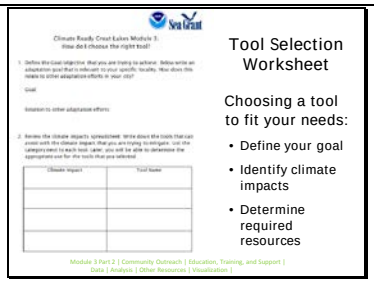
Slide 87		Visualization tools represent data graphically and can make the information easier to understand. This is key in adaption planning, because it allows information to be shared with the public, internal partners, and external partners. This capability can be valuable at any point in the planning 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)
Slide 88		A screen shot of the CanVis program's interface; the photo was selected from the CanVis image library.
Slide 89		CanVis is a NOAA Digital Coast software program that creates a visual display of landscape changes. Images help users determine potential impacts of a project. The cost is free, and it requires a three-hour virtual training seminar. Training is conducted via WebEx, which requires internet, phone, and WebEx software.
Slide 90		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

Slide 91		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
Slide 92		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)
Slide 93		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.
Slide 94		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)
Slide 95		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: University of Wisconsin. "Coastal Erosion on the Great Lakes," http://www.geography.wisc.edu/coastal/ (accessed December 28, 2010)

Slide 96		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)
Slide 97		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.
Slide 98		This slide shows the CanVis interface. Toolbars allow you to design and create a scene.
Slide 99		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/

Slide 100		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.
Slide 101		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.
Slide 102		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.
Slide 103		Next, you can identify the areas in the photo that need to be a different texture. These include things like pavers, groundcover, and sod.
Slide 104		The software allows you to define the dimensions of an area to cover. Once an area is selected, the area will turn grey.

Slide 105		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.
Slide 106	Perspective and Scale 	Perspective and scale can be altered to make the newly textured area look like it is going off into the distance.
Slide 107	Adding Objects 	• 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. The Integration 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.
Slide 108		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.

Slide 109		At left, the original image. At right, the finished product created in CanVis.
Slide 110		The information presented in this module should help you get started on choosing and using tools for your own community's adaptation plan.
Slide 111		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)
Slide 112		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.

Source: National Oceanic and Atmospheric Administration (NOAA). 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

Appendix A: Potential Federal Funding Sources

The programs in the table below are examples of the types of programs that may provide funding indirectly or directly for activities that support climate change adaptation. The list is not comprehensive, and availability of funds may vary from one year to the next. General contact information is provided, but, in most cases, your best contact is the parallel state agency or the regional federal office. An ongoing monitoring of Grants.gov is a good way to keep up with federal funding opportunities.

Program Name/ CFDA Number	Description	Contact Information
Grants.gov	Source to find and apply for federal government grants.	Grants.gov www.grants.gov/
Catalog of Federal Domestic Assistance	Database of federal programs.	Catalog of Federal Domestic Assistance www.cfda.gov/
U.S. Department of Commerce		
Coastal Zone Management Administration Awards CFDA 11.419	Financial assistance for implementation and enhancement of state coastal management programs, which aim to preserve, protect, develop, and where possible restore and enhance the resources of the nation's coastal zone.	NOAA/National Ocean Service Office of Ocean and Coastal Resource Management (301) 713-3155 http://coastalmanagement.noaa.gov/programs/czm.html
Coastal and Estuarine Land Conservation Program CFDA 11.419	Financial assistance for land acquisition to protect important coastal and estuarine areas that have significant conservation, recreation, ecological, historical, or aesthetic values, or that are threatened by conversion from their natural or recreational state to other uses.	NOAA/National Ocean Service Office of Ocean and Coastal Resource Management (301) 713-3155 http://coastalmanagement.noaa.gov/land/
Coral Reef Conservation Grant Program CFDA 11.419	Financial assistance for broad-based coral reef conservation activities (including management and monitoring).	NOAA/National Ocean Service Office of Ocean and Coastal Resource Management (301) 713-3155 http://coralreef.noaa.gov/aboutcrcp/workwithus/funding/welcome.html

Program Name/ CFDA Number	Description	Contact Information
U.S. Department of Commerce (cont'd)		
National Estuarine Research Reserve CFDA 11.420	Financial assistance for development, land acquisition, monitoring, research, education, operation, and facilities construction for National Estuarine Research Reserves for the purpose of creating natural field laboratories to gather data and make studies of and educate people about the natural and human processes occurring within the estuaries of the coastal zone.	NOAA/National Ocean Service Office of Ocean and Coastal Resource Management (301) 713-3155 http://nerrs.noaa.gov/
Community-Based Restoration Program CFDA 11.463	Financial assistance to implement on-the-ground habitat restoration projects to benefit marine, estuarine, and riparian habitats, including but not limited to salt marshes, seagrass beds, coral reefs, mangrove forests, and freshwater habitat important to anadromous fisheries, predominantly in coastal areas around the United States.	NOAA/National Marine Fisheries Service Office of Habitat Conservation (301) 713-0174 www.habitat.noaa.gov/funding/crp.html
Climate and Societal Interactions Program CFDA 11.431	Financial assistance for research, outreach, and education activities that enhance the capacity of key socioeconomic sectors to respond to and plan for a changing climate through the use of climate information and related decision-support resources.	NOAA/Office of Oceanic and Atmospheric Research Climate Program Office www.cpo.noaa.gov/cpo_pa/
Economic Adjustment Assistance Program CFDA 11.307	Financial assistance to address the needs of communities experiencing adverse economic changes that may occur suddenly or over time, including but not limited to those caused by federally declared disasters.	Economic Development Administration[1] www.eda.gov/AboutEDA/Programs.xml
Public Works and Economic Development Program CFDA 11.300	Financial assistance to help the nation's most distressed communities revitalize, expand and upgrade their physical infrastructure to attract new industry, encourage business expansion, diversify local economies, and generate or retain long-term private sector jobs and investments.	Economic Development Administration[1] www.eda.gov/AboutEDA/Programs.xml

Program Name/ CFDA Number	Description	Contact Information
U.S. Department of Homeland Security		
Hazard Mitigation Grant Program CFDA 97.039	Financial assistance to implement long-term hazard mitigation measures to reduce the loss of life and property after a major disaster declaration.	Federal Emergency Management Agency[2] Risk Reduction Division (866) 222-3580 hmagrantshelpline@dhs.gov www.fema.gov/government/grant/hmgp/
Pre-Disaster Mitigation Program CFDA 97.047	Financial assistance for hazard mitigation planning and the implementation of hazard mitigation projects that reduce injuries, loss of life, and damage and destruction of property prior to a disaster.	Federal Emergency Management Agency[2] Risk Reduction Division (866) 222-3580 hmagrantshelpline@dhs.gov www.fema.gov/government/grant/pdm/
Flood Mitigation Assistance Program CFDA 97.029	Financial assistance to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the National Flood Insurance Program (NFIP). The long-term goal is to reduce or eliminate claims under the NFIP through mitigation activities.	Federal Emergency Management Agency[2] Risk Reduction Division (866) 222-3580 hmagrantshelpline@dhs.gov www.fema.gov/government/grant/fma/
Repetitive Flood Claims Program CFDA 97.092	Financial assistance to reduce or eliminate the long-term risk of flood damage to structures insured under the NFIP that have had one or more claims for flood damage and that cannot meet the requirements of the Flood Mitigation Assistance program for either cost-share or capacity to manage the activities.	Federal Emergency Management Agency[2] Risk Reduction Division (866) 222-3580 hmagrantshelpline@dhs.gov www.fema.gov/government/grant/rfc/
Severe Repetitive Loss Program CFDA 97.110	Financial assistance to reduce or eliminate the long-term risk of flood damage to severe repetitive loss structures insured under the NFIP.	Federal Emergency Management Agency[2] Risk Reduction Division (866) 222-3580 hmagrantshelpline@dhs.gov www.fema.gov/government/grant/srl/
Public Assistance Grant Program CFDA 97.036	Financial assistance so communities can quickly respond to and recover from major disasters or emergencies declared by the President, includes funding for the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain private nonprofit organizations and encourages their protection from future events by providing assistance for hazard mitigation during the recovery process.	Federal Emergency Management Agency[2] Public Assistance Division www.fema.gov/government/grant/pa/

Program Name/ CFDA Number	Description	Contact Information
U.S. Department of Homeland Security (cont'd)		
Community Assistance Program State Support Services Element CFDA 97.023	Financial assistance to states to provide technical assistance to NFIP communities and to evaluate community performance in implementing NFIP floodplain management activities with the additional goal of building state and community floodplain management expertise and capability.	Federal Emergency Management Agency[2] www.fema.gov/plan/prevent/floodplain/fema_cap-ssse.shtm
U.S. Environmental Protection Agency		
Wetland Program Development Grants CFDA 66.461; 66.462	Financial assistance to enhance and build programs that protect, manage, and restore wetlands.	Office of Wetlands, Oceans, and Watersheds[3] (800) 832-7828 wetlands.helpline@epa.gov www.epa.gov/owow/wetlands/
National Estuary Program CFDA 66.456	Financial assistance to protect and restore estuaries and estuarine watersheds designated by the EPA administrator as estuaries of national significance.	Office of Wetlands, Oceans, and Watersheds[3] www.epa.gov/owow/estuaries/
Nonpoint Source Implementation Grants CFDA 66.460	Financial assistance for implementing EPA-approved Section 319 nonpoint source management programs.	Office of Wetlands, Oceans, and Watersheds[3] (202) 566-1155 www.epa.gov/owow/nps/cwact.html
U.S. Department of Defense		
Estuary Habitat Restoration Program	Financial and technical assistance for estuary habitat restoration projects that result in improving degraded estuaries or estuary habitat or creating estuary habitat, with the goal of attaining a self-sustaining system integrated into the surrounding landscape.	U.S. Army Corps of Engineers[4] Civil Works www.usace.army.mil/CECW/ERA/
Beach Erosion Control Projects CFDA 12.101	Financial and technical assistance to control beach and shore erosion to public shores through projects not specifically authorized by Congress.	U.S. Army Corps of Engineers[4] Civil Works
Flood Control Projects CFDA 12.106	Financial and technical assistance to reduce flood damages through projects not specifically authorized by Congress.	U.S. Army Corps of Engineers[4] Civil Works
Aquatic Plant Control CFDA 12.100	Financial and technical assistance for the control of obnoxious aquatic plants in rivers, harbors, and allied waters. The program is designed to deal primarily with weed infestations of major economic significance.	U.S. Army Corps of Engineers Aquatic Plant Control Operations Support Center (800) 291-9405

Program Name/ CFDA Number	Description	Contact Information
U.S. Department of Defense (cont'd)		
Protection of Essential Highways, Highway Bridge Approaches, and Public Works CFDA 12.105	Financial and technical assistance to provide bank protection of highways, highway bridges, essential public works, churches, hospitals, schools, and other nonprofit public services endangered by flood-caused erosion.	U.S. Army Corps of Engineers[4] Civil Works
Snagging and Clearing for Flood Control CFDA 12.108	Financial and technical assistance to reduce flood damages by channel clearing and excavation, with limited embankment construction by use of materials from the clearing operation only.	U.S. Army Corps of Engineers[4] Civil Works
Aquatic Ecosystem Management and Restoration	Financial and technical assistance to restore degraded aquatic ecosystem structure, function, and dynamic processes to a less degraded, more natural condition, which will involve consideration of the ecosystem's natural integrity, productivity, stability, and biological diversity.	U.S. Army Corps of Engineers[4] Civil Works
Beneficial Uses of Dredged Materials	Financial and technical assistance to protect, restore, and create aquatic and wetland habitats in connection with dredging of an authorized navigation project.	U.S. Army Corps of Engineers[4] Civil Works
Project Modifications for Improvement of the Environment	Financial and technical assistance for planning, engineering and design, and construction of projects to restore ecosystems degraded by a previously constructed Corps of Engineers project. Projects typically involve environmental restoration of aquatic, floodplain, and upland areas.	U.S. Army Corps of Engineers[4] Civil Works
U.S. Department of the Interior		
North American Wetlands Conservation Act CFDA 15.623	Financial assistance for long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats.	U.S. Fish and Wildlife Service[5] Division of Bird Habitat Conservation (703) 358-1784 dbhc@fws.gov www.fws.gov/birdhabitat/Grants/NAWCA/
National Coastal Wetlands Conservation Grant Program CFDA 15.614	Financial assistance for acquisition, restoration, management, or enhancement of coastal wetlands.	U.S. Fish and Wildlife Service[5] Division of Habitat and Resource Conservation (703) 358-2236 www.fws.gov/coastal/CoastalGrants/

Program Name/ CFDA Number	Description	Contact Information
U.S. Department of the Interior (cont'd)		
Cooperative Endangered Species Conservation Fund CFDA 15.615	Financial assistance for a wide array of voluntary conservation projects for candidate, listed, and recently recovered species. Projects include habitat restoration, species status surveys, public education and outreach, captive propagation and reintroduction, nesting surveys, genetic studies, development of management and habitat conservation plans, and land acquisition.	U.S. Fish and Wildlife Service Endangered Species Program[6] www.fws.gov/endangered/grants/
State (Tribal) Wildlife Grants CFDA 15.634; 15.639	Financial assistance to develop and implement programs for the benefit of wildlife and their habitat.	U.S. Fish and Wildlife Service[5] Wildlife and Sport Fish Restoration Program http://wsfrprograms.fws.gov/Subpages/GrantPrograms/GrantProgramsIndex.htm
Landowner Incentive Program CFDA 15.633	Financial assistance to establish or supplement landowner incentive programs that provide technical or financial assistance to private landowners for the protection and management of habitat to benefit federally listed, proposed, or candidate species, or other at-risk species on private lands.	U.S. Fish and Wildlife Service[5] Wildlife and Sport Fish Restoration Program http://wsfrprograms.fws.gov/Subpages/GrantPrograms/GrantProgramsIndex.htm
Land and Water Conservation Fund CFDA 15.916	Financial assistance for the preparation of statewide comprehensive outdoor recreation plans and acquisition and development of outdoor recreation areas and facilities.	National Park Service[7] www.nps.gov/ncrc/programs/lwcf/
U.S. Department of Housing and Urban Development		
Community Development Block Grant Program CFDA 14.218; 14.228	Financial assistance for the development of viable urban communities, which means providing decent housing and a suitable living environment and by expanding economic opportunities, principally for persons of low- and moderate-income. Under certain circumstances, funding may be used to meet urgent needs where existing conditions pose a serious and immediate threat to the health or welfare of the community.	Community Planning and Development[8] www.hud.gov/offices/cpd/communitydevelopment/programs/

Program Name/ CFDA Number	Description	Contact Information
U.S. Department of Agriculture		
Urban and Community Forestry Program CFDA 10.675	Financial assistance to plan for, establish, manage, and protect trees, forests, green spaces, and related natural resources in and adjacent to cities and towns.	U.S. Forest Service[9] State and Private Forestry www.fs.fed.us/spf/
Watershed Protection and Flood Prevention CFDA 10.904	Financial and technical assistance for works of improvement to protect, develop, and utilize the land and water resources in watersheds.	Natural Resources Conservation Service[10] Conservation Planning and Technical Assistance Division www.nrcs.usda.gov/programs/watershed/

Regional Contacts:

[1] www.eda.gov/AboutEDA/Regions.xml
[2] www.fema.gov/about/regions/
[3] www.epa.gov/epahome/regions.htm
[4] www.usace.army.mil/about/Pages/Locations.aspx
[5] www.fws.gov/coastal/CoastalGrants/contactUs.html
[6] www.fws.gov/endangered/regions/
[7] www.nps.gov/ncrc/programs/lwcf/contact_list.html
[8] www.hud.gov/offices/cpd/about/staff/fodirectors/
[9] www.fs.fed.us/ucf/contact_regional.html
[10] www.nrcs.usda.gov/about/directory/specialists.html

Source: National Oceanic and Atmospheric Administration (NOAA). 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

Appendix B: Federal Laws and Executive Orders Relevant to Climate Change on the Coast

Some of the federal laws and presidential executive orders that are relevant to climate change on the coast are summarized below. They are listed alphabetically and encompass all amendments. Dates indicate the year the law was originally passed.

Laws as codified can be accessed at http://uscode.house.gov/lawrevisioncounsel.shtml. Executive orders can be accessed at www.archives.gov/federal-register/executive-orders/.

Laws

Title	Description	Lead Agency(s)
Clean Water Act (Federal Water Pollution Control Act) (1972) 33 U.S.C. 1251 et seq.	Established the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Includes a program to regulate the discharge of dredged and fill material into waters of the United States, including wetlands. Provides loans and grants to local governments for wastewater treatment, nonpoint source pollution control, and estuary protection.	• U.S. Army Corps of Engineers • U.S. Environmental Protection Agency
Coastal Barrier Resources Act (1982) 16 U.S.C. 3501 et seq.	Restricts federal expenditures that might encourage or support development, including flood insurance, within the Coastal Barrier Resources System, which consists of undeveloped coastal barriers along the Atlantic, Gulf, and Great Lakes coasts.	• U.S. Fish and Wildlife Service
Coastal Wetlands Planning, Protection, and Restoration Act (1990) 16 U.S.C. 3951 et seq.	Established the National Coastal Wetlands Conservation Grant Program to provide funding for acquisition, restoration, management and enhancement of coastal wetlands.	• U.S. Fish and Wildlife Service
Coastal Zone Management Act (1972) 16 U.S.C. 1451 et seq.	Provides for management of coastal resources, including the Great Lakes, and balances economic development with environmental conservation. Outlines and provides financial support for the National Coastal Zone Management Program and the National Estuarine Research Reserve System. Recognizes the need for coastal states to anticipate and plan for sea level rise.	• NOAA/National Ocean Service

Title	Description	Lead Agency(s)
Coral Reef Conservation Act (2000) 16 U.S.C. 6401 et seq.	Established the National Coral Reef Action Strategy, Coral Reef Conservation Program, and Coral Reef Conservation Fund to provide funding and promote effective management and use of sound science to preserve, sustain, and restore valuable coral reef ecosystems.	• NOAA/National Ocean Service
Endangered Species Act (1973) 16 U.S.C. 1531 et seq.	Provides for the conservation of endangered and threatened species of fish, wildlife, and plants and the ecosystems on which they depend. Authorizes the determination and listing of species as endangered and threatened. Prohibits unauthorized taking, possession, sale, and transport of endangered species. Provides funding to acquire land for the conservation of listed species and to support state programs.	• NOAA/National Marine Fisheries Service • U.S. Fish and Wildlife Service
Estuary Protection Act (1968) 16 U.S.C. 1221 et seq.	Encourages consideration in planning and development activities of the value of estuaries and the need to protect, conserve, and restore them.	• U.S. Fish and Wildlife Service
Estuary Restoration Act (2000) 33 U.S.C. 2901 et seq.	Made restoring estuaries a national priority. Promotes the restoration of estuary habitat by forging effective partnerships among public agencies and between the public and private sectors, providing financial and technical assistance for estuary habitat restoration projects, and developing and enhancing monitoring and research capabilities.	• Natural Resources Conservation Service • NOAA/National Marine Fisheries Service/National Ocean Service • U.S. Army Corps of Engineers • U.S. Environmental Protection Agency • U.S. Fish and Wildlife Service
Federal Water Project Recreation Act (1965) 16 U.S.C. 4601K-12 et seq.	Requires that recreation and fish and wildlife enhancement be given full consideration in federal water development projects (e.g., navigation, flood control, reclamation, hydroelectric projects). Authorizes funding for land acquisition to establish refuges for migratory waterfowl.	• U.S. Fish and Wildlife Service
Fish and Wildlife Coordination Act (1934) 16 U.S.C. 661 et seq.	Provides for protection of fish and wildlife when federal actions result in the control or modification of a natural stream or body of water. Requires federal agencies to consider the effect that water-related projects would have on fish and wildlife resources, take action to prevent loss or damage to these resources, and provide for the development and improvement of these resources.	• NOAA/National Marine Fisheries Service • U.S. Fish and Wildlife Service
Fish and Wildlife Conservation Act (1980) 16 U.S.C. 2901 et seq.	Authorizes financial and technical assistance to states for development, revision, and implementation of conservation plans and programs for nongame fish and wildlife.	• U.S. Fish and Wildlife Service
Magnuson-Stevens Fishery Conservation and Management Act (1976) 15 U.S.C. 1801 et seq.	Provides for management and conservation of marine fisheries in U.S. federal waters through regional fishery management councils. Promotes rebuilding overfished fisheries, protecting essential fish habitat, and reducing bycatch. Mandates the use of annual catch limits and accountability measures to end overfishing.	• NOAA/National Marine Fisheries Service

Title	Description	Lead Agency(s)
Marine Mammal Protection Act (1972) 16 U.S.C. 1361 et seq.	Restricts the taking and importing of marine mammals and marine mammal products. Calls for an ecosystem approach to natural resource management and conservation.	• NOAA/National Marine Fisheries Service • U.S. Fish and Wildlife Service
National Environmental Policy Act (1969) 42 U.S.C. 4321 et seq.	Requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions (including financing) and reasonable alternatives to those actions.	• U.S. Environmental Protection Agency
National Flood Insurance Act (1968) 42 U.S.C. 4001 et seq.	Established the National Flood Insurance Program to provide protection (insurance) against flood losses and encourage sound land use. Requires communities to participate in the flood insurance program as a condition of future federal financial assistance. Requires the purchase of flood insurance by property owners who are being assisted by federal programs or by federally supervised, regulated, or insured agencies or institutions in the acquisition or improvement of land or facilities (e.g., mortgages) in special flood hazard areas.	• Federal Emergency Management Agency
National Historic Preservation Act (1966) 16 U.S.C. 470 et seq.	Directs federal agencies to consider the effects of their actions (including financing) on historic properties (e.g., districts, buildings, structures, sites, or objects) in their decision making.	• National Park Service
National Marine Sanctuaries Act (1972) 16 U.S.C. 1431 et seq.	Authorizes the designation and protection of areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational, or aesthetic qualities as national marine sanctuaries.	• NOAA/National Ocean Service
National Park Service Organic Act (1916) 16 U.S.C. 1 et seq.	Established the National Park Service to conserve, promote, and regulate the use of federal areas designated as part of the Natural Park System.	• National Park Service
National Wildlife Refuge System Administration Act (1966) 16 U.S.C. 668dd, 668ee	Provides for the administration and management of the national wildlife refuge system, including wildlife refuges, areas for the protection and conservation of fish and wildlife threatened with extinction, wildlife ranges, game ranges, wildlife management areas and waterfowl production areas.	• U.S. Fish and Wildlife Service
Non-Indigenous Aquatic Nuisance Prevention and Control Act (1990) 16 U.S.C. 4701 et seq.	Provides for prevention and control of infestations of the coastal inland waters of the United States by the zebra mussel and other nonindigenous aquatic nuisance species through ballast water management, research, and financial assistance.	• NOAA • U.S. Army Corps of Engineers • U.S. Coast Guard • U.S. Fish and Wildlife Service • U.S. Environmental Protection Agency

Title	Description	Lead Agency(s)
North American Wetlands Conservation Act (1989) 16 U.S.C. 4401 et seq.	Provides for the conservation of North American wetland ecosystems for waterfowl, other migratory birds, fish, and wildlife through a nonregulatory, incentive-based program that encourages public-private partnerships and provides financial assistance for projects.	• U.S. Fish and Wildlife Service
Resource Conservation and Recovery Act (1976) 42 U.S.C. 6901 et seq.	Authorizes control of hazardous waste generation, transportation, treatment, storage, and disposal. Establishes a framework for the management of nonhazardous solid waste.	• U.S. Environmental Protection Agency
Rivers and Harbors Appropriation Act (1899) 33 U.S.C. 401 et seq.	Prohibits navigational obstructions, including alteration (e.g., excavation and fill) of the course, location, condition, or capacity of any navigable water of the United States. Regulates the construction of wharves, piers, jetties, bulkheads, and similar structures in ports, rivers, canals, or other areas used for navigation.	• U.S. Army Corps of Engineers
Robert T. Stafford Disaster Relief and Emergency Assistance Act (1974) 42 U.S.C. 5121 et seq.	Established the process through which the federal government provides assistance to state and local governments to alleviate the suffering and damage which result from disasters. Encourages and provides funding for hazard mitigation and requires state and local hazard mitigation plans for some types of assistance.	• Federal Emergency Management Agency
Safe Drinking Water Act (1974) 42 U.S.C. 300f et seq.	Authorized establishment of national health-based standards to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and ground water wells.	• U.S. Environmental Protection Agency
Water Resources Development Act (multiple years) 33 U.S.C. 2201 et seq.	Authorizes funding for water-related projects, including beach nourishment, clean water, and flood control programs.	• U.S. Army Corps of Engineers
Watershed Protection and Flood Prevention Act (1954) 16 U.S.C. 1001 et seq.	Authorizes technical and financial assistance to state and local governments for planning and installing watershed projects to address natural resource issues such as flooding and sedimentation.	• Natural Resources Conservation Service
Wild and Scenic Rivers Act (1968) 16 U.S.C. 1271 et seq.	Established the National Wild and Scenic Rivers System to protect and preserve rivers that possess scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values as well as their immediate environments.	• Bureau of Land Management • National Park Service • U.S. Fish and Wildlife Service • U.S. Forest Service

Executive Orders

Title	Description
Executive Order 11988 Floodplain Management (1977) Codified under 42 U.S.C. 4321	Directs federal agencies to provide leadership and take action to reduce the risk of flood loss; to minimize the impact of floods on human safety, health, and welfare; and to restore and preserve the natural and beneficial values served by floodplains by evaluating the potential effects of any actions (federally conducted, approved, or funded) they may take in a floodplain and avoiding harm where practicable.
Executive Order 11990 Protection of Wetlands (1977) Codified under 42 U.S.C. 4321	Directs federal agencies to provide leadership and take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands by evaluating the potential effects of any actions (federally conducted, approved, or funded) they may take in a wetland and avoiding harm where practicable.
Executive Order 12898 Environmental Justice (1994) Codified under 42 U.S.C. 4321	Directs federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.
Executive Order 13089 Coral Reef Protection (1998) Codified under 16 U.S.C. 6401	Established the United States Coral Reef Task Force to lead U.S. efforts to preserve and protect coral reef ecosystems. Directs federal agencies to ensure, to the extent practicable, that actions they authorize, fund, or carry out do not degrade these ecosystems.
Executive Order 13112 (1999) Codified under 42 U.S.C. 4321	Established the Invasive Species Council. Requires federal agencies to address invasive species concerns and to not authorize or carry out new actions that would cause or promote the introduction of invasive species to minimize the economic, ecological, and human health impacts that invasive species cause.
Executive Order 13158 Marine Protected Areas (2000) Codified under 16 U.S.C 1431	Established the Marine Protected Areas Center. Directs federal agencies to work with government and nongovernmental partners to increase protection and sustainable use of ocean resources by strengthening and expanding a national system of marine protected areas (MPA). Directs federal agencies to avoid harm to MPAs through the actions they authorize, fund, or carry out.
Executive Order 13514 Federal Leadership in Environmental, Energy, and Economic Performance (2009)	Requires agencies to participate in the interagency Climate Change Adaptation Task Force to develop a U.S. strategy for adaptation to climate change and approaches through which the policies and practices of the agencies can be made compatible with and reinforce the strategy.
Executive Order 13547 Stewardship of the Ocean, Our Coasts, and the Great Lakes (2010)	Establishes a national policy to ensure the protection, maintenance, and restoration of the health of ocean, coastal, and Great Lakes ecosystems and resources, enhance the sustainability of ocean and coastal economies, preserve our maritime heritage, support sustainable uses and access, provide for adaptive management to enhance our understanding of and capacity to respond to climate change and ocean acidification, and coordinate with our national security and foreign policy interests.

APPENDIX C: 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
Shauna Casey
Danielle Forsyth
Rebecca Held
Sara Katich
Dawn Nelson
Cybelle Shattuck
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.

Climate Ready Great Lakes: Module Development

Module 1: What am I Adapting To?
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: Developing a Climate 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: Climate Change Adaptation Tools
Highlights tools that have been developed by NOAA, Sea Grant and other 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., Peterson, T. (Eds.) 2009. Global Climate Change Impacts in the United States. U.S. Global Change Research Program. Cambridge University Press, 2009.

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=100343623

4&_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, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

"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."

Additional References from Climate Impacts Slides from *Climate Ready Great Lakes*

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 anthro- pogenic 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. "Vulnerability." *Global Environmental Change*. Vol. 16. No 3. 268-281. Aug. 2006.

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
Committee on Disaster Research in the Social Sciences: Future Challenges and Opportunities, National Research Council. Washington DC: The National Academies, 2006

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. Panel on Strategies and Methods for Climate-Related Decision Support; National Research Council. Washington DC: The National Academies Press, 2009.

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. "Adaptation, adaptive capacity and vulnerability." *Global Environmental Change* 16 (2006) (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. "Mapping Community Determinants of Heat Vulnerability." *Environmental Health Perspectives*. Vol. 117. No. 11: 1730-1736. NOV 2009

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. Environment Canada: Ottawa, ON. 2006

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. *Implications of climate change for coastal fishes and habitats.* Annual Conference on Great Lakes Research. Vol. 49, 2006.

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. *Vulnerability of Great Lakes Coastal Wetland Vegetation Communities to Water Level Fluctuations.* Annual Conference on Great Lakes Research. Vol. 49, 2006.

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. "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. 2006

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

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. "Towards an integrated framework for assessing the vulnerability of species to climate change." *PLoS Biology* 6:2621-2626. Dec. 2008

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. "Successful adaptation to climate change across scales." *Global Environmental Change* 15:77-86. 2005

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 (NOAA). 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. *Informing Decisions in a Changing Climate*. Panel on Strategies and Methods for Climate-Related Decision Support. 2009.

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. "Moving from agenda to action: evaluating local climate change action plans." Journal of Environmental Planning and Management, Volume 53, Issue 1 January 2010. Pp. 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. Keywords: climate change; local jurisdiction; action plan; quality

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. "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. 2008

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. "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. Oct 2001.

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. "Mitigation Strategies and Unforeseen Consequences: A Systematic Assessment of the Adaptation of Upper Midwest Agriculture to Future Climate Change." *World Resource Review*. Vol. 9, no. 4, 447 p. Dec 1997.

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.

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. *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 May 2003. 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. *Urban Stormwater Management in the United States*. Washington DC: The National Academies Press, 2009 (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

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 *Drought Planning for Small Community Water Systems*. Prepared for the Midwest Technology Assistance Center. Feb. 2006. 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. Cities, Climate Change and Urban Heat Island Mitigation: Localising Global Environmental Science. *Urban Studies* 46, no. 2 (2009): 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. "Heat-related mortality during a 1999 heat wave in Chicago." *American Journal of Preventive Medicine*. Vol 22, Issue 4: 221-227. (May 2002)

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. "The 2003 heat wave in France: Dangerous climate change here and now." *Risk Analysis*. Vol 25, Issue 6: 1483-94. Dec. 2005.

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. Urban Heat and Air Pollution: An Emerging Role for Planners in the Climate Change Debate. *Journal of the American Planning Association.* Chicago: Winter 2005. 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. *Coastal zone and Climate Change on the Great Lakes: Final Report*. Natural Resources Canada, 2006

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.

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.

Ecosystem Resiliency

Chicago Wilderness Climate Change Task Force. "Chicago Wilderness Climate Action Plan for Nature." March 1, 2010
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.

Doka, S., J. Ingram, L. Mortsch, A. Hebb. "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. 2006

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 *A New Era for Conservation: Review of Climate Change Adaptation Literature*. National Wildlife Federation, March 12, 2009

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

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. "Land use planning." In *Great Lakes coastal wetland communities: vulnerabilities to climate change and response to adaptation strategies*. pp. 229-247. 2006.

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.

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. "Resilience: the emergence of a perspective for social–ecological systems analyses." *Global Environmental Change* 16 (2006) (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. *Making Collaboration Work: Lessons from Innovation in Natural Resource Management*. Washington DC: Island Press, 2000

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. Sci 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. Dev. 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. Sci. 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 *2, p (x* > a) and *p(b* > **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. J. 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