

The State of Climate Change Adaptation in the Great Lakes Region



Rachel M. Gregg, Kirsten M. Feifel, Jessi M. Kershner, and Jessica L. Hitt

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Table of Contents

| | |
|--|-----------|
| Executive Summary | 2 |
| Introduction | 4 |
| Climate Change and the Great Lakes Region | 6 |
| Air Temperature | 10 |
| Lake Temperature and Ice Cover | 13 |
| Precipitation | 15 |
| Lake Levels | 16 |
| Water Chemistry | 17 |
| Adaptation Projects and Programs in the Great Lakes Region | 20 |
| Adaptation Projects and Initiatives | 20 |
| Capacity Building | 22 |
| Design or reform institutions | 22 |
| Conduct research, studies, and assessments | 27 |
| Conduct training and planning exercises | 31 |
| Increase/improve public awareness, education, and outreach efforts | 34 |
| Create/enhance resources and tools | 36 |
| Monitor climate change impacts and adaptation efficacy | 39 |
| Policy..... | 41 |
| Develop/implement adaptation plans | 41 |
| Create new or enhance existing policies or regulations | 43 |
| Develop/implement adaptive management strategies | 45 |
| Natural Resource Management and Conservation..... | 47 |
| Incorporate climate-smart guidelines into restoration | 47 |
| Enhance connectivity and areas under protection..... | 48 |
| Reduce local climate or related change..... | 49 |

| | |
|--|-----------|
| Reduce non-climate stressors likely to interact with climate change | 50 |
| Infrastructure, Planning, and Development | 53 |
| Make infrastructure resistant or resilient to climate change | 53 |
| Community planning (developing climate-smart communities)..... | 55 |
| Create or modify shoreline management measures | 57 |
| Develop disaster preparedness plans and policies | 58 |
| Regional Challenges and Opportunities | 59 |
| Conclusion | 62 |
| Appendices | 63 |
| A. Climate Change Adaptation Literature | 64 |
| B. State of Adaptation Methodology | 65 |
| C. Adaptation Case Studies from the Great Lakes Region (by strategy)..... | 67 |
| D. Adaptation Case Studies Compendium..... | 76 |
| A Roadmap for Action: The Chicago Climate Action Plan..... | 79 |
| Adapting to Climate Change in Ontario Parks..... | 83 |
| Addressing Climate Change Impacts in the Great Lakes Water Quality Agreement | 87 |
| Addressing Climate Change in the International Upper Great Lakes Study..... | 90 |
| Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise and Lake Level Changes..... | 92 |
| Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed..... | 94 |
| Canada’s Regional Adaptation Collaboratives Climate Change Program..... | 97 |
| ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State.. | 99 |
| Climate Adaptation in the City of Ann Arbor, Michigan..... | 103 |
| Climate Change Adaptation Planning at the State Level in Minnesota..... | 106 |
| Climate Change Adaptation Planning at the State Level in Pennsylvania | 109 |
| Climate Change and Coastal Adaptation Options for the Great Lakes | 112 |

| | |
|--|-----|
| Climate Change Mitigation and Adaptation Planning in Wisconsin’s Lake Michigan Coastal Communities..... | 115 |
| Climate Change, the Great Lakes, and Mining..... | 117 |
| Climate Consortium for Research Action and Integration (CC-RAI)..... | 119 |
| Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force..... | 121 |
| Developing a Climate Change Adaptation Plan for Forest and Water Resources in Alger County, Michigan | 124 |
| Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States..... | 127 |
| Developing Ontario’s Climate Change Adaptation Strategy and Action Plan..... | 129 |
| Enhancing Climate Change Education and Outreach for Wisconsin’s Coastal Communities | 132 |
| Fish, Fisheries, and Water Resources: Adapting to Ontario’s Changing Climate..... | 134 |
| Fostering a Climate-Informed Community Perspective in the Great Lakes: The Great Lakes Community Climate Program | 139 |
| Great Lakes Adaptation Assessment for Cities..... | 142 |
| Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Adaptation Strategies..... | 145 |
| Great Lakes Observing System..... | 148 |
| Great Lakes Restoration Initiative..... | 150 |
| Helping Michigan’s Farmers Understand and Adapt to the Impacts of Climate Change..... | 153 |
| Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA) using GPS Telemetry..... | 156 |
| Incorporating Climate Change into TMDL Decisions for Lake Champlain | 158 |
| Integrating Climate Change into Municipal Watershed Management in Ontario | 161 |
| Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin..... | 164 |
| Integrating Climate Change into Water Quality Monitoring on the Fond du Lac Reservation in Minnesota..... | 167 |
| Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds | 169 |

| | |
|---|-----|
| London, Ontario’s Climate Change Adaptation Strategy | 171 |
| New York’s Climate Smart Communities Program | 173 |
| Ontario Regional Adaptation Collaborative | 175 |
| Pennsylvania Sea Grant’s Climate Change Outreach and Research Projects..... | 177 |
| Planning for Climate Change in the Province of Quebec | 180 |
| Preparing for Climate Change in the Great Lakes Region | 183 |
| Project Clean Lake: Updating Cleveland’s Sewer Systems to Reduce Stormwater Overflows | 186 |
| Quebec City’s Environmental Services Adaptation Plan..... | 188 |
| Quebec Regional Adaptation Collaborative | 190 |
| Rein in the Runoff: Michigan’s Spring Lake Stormwater Management Project | 192 |
| Sustaining Lakes in a Changing Environment (SLICE): A Long-term Monitoring and Evaluation Program | 195 |
| The Chicago Wilderness Climate Action Plan for Nature | 198 |
| The City of Toronto’s Climate Change Adaptation Strategy: From Development to Implementation | 201 |
| The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region | 205 |
| The Michigan Climate Coalition: Enhancing Networking and Collaboration, Communication, and Action Around Climate Change in Michigan | 208 |
| The National Oceanic and Atmospheric Administration’s Great Lakes Climate Initiatives | 210 |
| The National Wildlife Federation’s Climate-Smart Restoration Partnership in the Great Lakes | 213 |
| The Ontario Centre for Climate Impacts and Adaptation Resources’ Climate Adaptation Initiatives | 216 |
| U.S. Global Change Research Program..... | 220 |
| Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio..... | 223 |
| Using Green Infrastructure to Prevent Sewage Overflows in Detroit..... | 226 |
| Water Supply Planning for Illinois | 229 |
| Weather–Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study | 232 |

Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate
Change Adaptation Strategies235

Executive Summary

Climate change is one of the most pressing issues of our time. It is a global problem that threatens the success and longevity of conservation and management actions. Strategies undertaken to address the causes and effects of global climate change are classified as either *mitigation* or *adaptation*.

Mitigation strategies help reduce the rate and extent of change by reducing greenhouse gas emissions or enhancing carbon uptake and sequestration. Adaptation strategies help people prepare for the unavoidable effects of climate change, either by minimizing negative impacts or exploiting potential opportunities. Adaptation, along with mitigation, is a critical component of any climate change response strategy.

The field of climate change adaptation is in a period of critical transition. The general concepts of adaptation have been well developed over the past decade. Now, practitioners must move from generalities to concrete actions, including implementation, monitoring, and evaluation. EcoAdapt strives to facilitate this transition by providing relevant adaptation examples and a forum for knowledge sharing. The purpose of EcoAdapt's State of Adaptation Program¹ is to promote adaptation action by (1) providing real-life, practical adaptation case studies to catalyze creative thinking, and (2) synthesizing information collected through interviews and surveys to further develop the field of study and action. We use the information collected to create synthesis reports, such as this one, and share the case studies and other resources through the Climate Adaptation Knowledge Exchange (CAKE; www.cakex.org), a website that supports open access information exchange between practitioners. CAKE includes case studies, a library, a community forum, a directory of individuals and organizations interested and/or engaged in adaptation, and a tools section of resources for adaptation action.

The intent of this report is to provide a brief overview of key climate change impacts and a review of the prevalent work occurring on climate change adaptation in the Great Lakes region, especially focusing on activities in the natural and built environments as they relate to freshwater resources (and in some cases, at the freshwater/terrestrial interface). This report presents the results of EcoAdapt's efforts to survey, inventory, and, where possible, assess adaptation activities in the Great Lakes region.

First, we provide a summary of climate change impacts and secondary effects on freshwater environments and resources in the Great Lakes region, specifically focusing on changes in air and water temperatures, precipitation patterns, lake levels, and water chemistry. We then provide summaries of and trends in commonly used adaptation approaches and examples from our survey and other resources. We separate these examples into four broad categories – *Capacity Building, Policy, Natural Resource Management and Conservation, and Infrastructure, Planning, and Development*.

¹ EcoAdapt's State of Adaptation Program <http://ecoadapt.org/programs/state-of-adaptation>

1. *Capacity Building*

Strategies include creating or reforming institutions, collecting additional information, conducting training and planning exercises, improving public awareness and education, developing tools and resources, and monitoring impacts and efficacy of adaptation action.

2. *Policy*

Strategies include developing adaptation plans, creating new or enhancing existing policies, and developing adaptive management strategies.

3. *Natural Resource Management and Conservation*

Strategies include incorporating climate change into restoration efforts, enhancing connectivity, reducing local change, and reducing non-climate stressors.

4. *Infrastructure, Planning, and Development*

Strategies include improving existing or designing new infrastructure to withstand the effects of climate change, incorporating climate change into community and land use planning, creating or modifying shoreline management measures, and preparing for disasters.

The report concludes with a discussion of the challenges to and opportunities for climate change adaptation in the Great Lakes region. The majority of adaptation efforts in the Great Lakes region thus far has been focused on capacity building, including improving understanding and awareness, acquiring or developing resources, and developing collaborative partnerships. Important next steps for advancing climate change adaptation in the Great Lakes region are to increase knowledge sharing between practitioners, to encourage more planning and integration across political and sectoral boundaries, to implement actions, and to monitor and evaluate the efficacy of these activities.

Introduction

The Great Lakes region is composed of two Canadian provinces – Ontario and Quebec; eight U.S. states – Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin; and the watersheds, lakes, and rivers that surround the five primary lakes – Superior, Michigan, Huron, Erie, and Ontario. This includes the St. Lawrence River, which is the primary outlet to the Atlantic Ocean, and several other rivers (e.g., Chicago, Calumet, St. Marys, St. Clair, Ottawa, Detroit, Niagara) and lakes (e.g., Saint Clair, Nipigon, Champlain).



Figure 1. Map of the Great Lakes basin, depicting lakes, rivers, and streams in the region (U.S. Army Corps of Engineers – Detroit District; retrieved from <http://gis.glin.net/maps>).

The region contains 21% of the world's freshwater supply and 84% of North America's surface freshwater supply.² Climate change is having and will continue to have significant effects on the freshwater resources and human communities in the region; these changes are manifesting in air and

² Environmental Protection Agency (EPA). Great Lakes Basic Information. <http://www.epa.gov/glnpo/basicinfo.html>

water temperatures, precipitation patterns, lake levels, and water chemistry. Direct and indirect effects of climate change will put various elements of the natural and built environments of the Great Lakes region at risk; many of these environments are already vulnerable because of non-climatic stressors, such as increased urban/suburban development, pollution, habitat degradation, and invasive species.

Practitioners need to prepare for and respond to these impacts through mitigation and adaptation measures. *Mitigation* refers to those efforts to reduce greenhouse gas emission reductions or enhance carbon storage; *adaptation* refers to those actions that aim to minimize the negative effects or exploit the potential opportunities presented by climate change. Neither mitigation nor adaptation alone will be sufficient; both approaches are needed for an integrated climate change response strategy. Practitioners in the Great Lakes region are utilizing both approaches to address climate change through capacity building, policy approaches, natural resource management actions, and planning efforts.

Climate Change and the Great Lakes Region

The burning of fossil fuels has emitted an estimated 500 billion metric tons of CO₂ into the atmosphere since the Industrial Revolution. The increased amount of atmospheric CO₂ and other greenhouse gases (e.g., methane, nitrous oxide) has altered the radiative balance of Earth and is changing temperatures, precipitation patterns, and water chemistry relative to pre-industrial times. These changes will have cascading and unforeseen consequences to regional freshwater resources and those that depend upon them.

While climate change is a global issue, the ramifications are often most detectable at regional and local scales. Unique regional features, such as the large, dynamic water bodies of the Great Lakes system, can make it difficult for scientists to construct exact predictions or establish empirical relationships between global changes and the local ramifications therein. In order to understand the consequences of climate change, impacts necessarily need to be considered at the regional or local level. In addition, climate change and other regional stressors, such as pollution and urban development, will have independent, synergistic, additive, or antagonistic effects with each other; for example, nutrient runoff from agricultural lands and urban areas has been identified as a leading cause of increased harmful algal blooms in the Great Lakes.³ Climate change is expected to increase water temperatures and enhance seasonal stratification in the Great Lakes; coupled with nutrient influx, these climatic changes will have additive effects on the occurrence of harmful algal blooms in the region.

There is an increasing awareness that climate change is impacting the Great Lakes region. However, direct attribution of regional-scale climate trends to anthropogenic influences is difficult due to the relative dearth of long-term records available to statistically delineate between natural variability and climate-induced change. Recent trends, both in the Great Lakes region and globally, strongly suggest that human-driven climate change is altering long-term climate patterns relative to historic norms. As atmospheric CO₂ accumulation continues to accelerate into the coming century and global change accelerates the many manifestations of climate change, the pace of change and associated impacts are expected to become more apparent. Many studies suggest that the positive impacts of climate change in the Great Lakes region, such as longer growing seasons or reduced wintertime energy consumption due to increased temperatures, will be largely outweighed by adverse effects, such as increased numbers of invasive species or more frequent heat waves.

In this section, we briefly examine Great Lakes characteristics (geography, climate, terrain, economy, stressors) before outlining some of the primary impacts expected in the region due to climate change. Changes considered include air temperature, lake temperature, precipitation patterns, lake level, water chemistry, and associated secondary impacts. Historic patterns are reviewed when possible and future trends are highlighted. Ultimately, the resultant future will be a complex

³ Committee on Environment and Natural Resources. (2010). Scientific Assessment of Hypoxia in U.S. Coastal Waters. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, D.C. <http://www.whitehouse.gov/sites/default/files/microsites/ostp/hypoxia-report.pdf>

interaction of fossil fuel emissions intensities, management strategies, biological responses, and any combination and interaction with other environmental stressors. Non-linear trends and extremes in climatic changes are important to consider. Predictive models and assessment reports such as this one can help to frame the future in a static world; in the end, however, the future will be an evolving process, continually painted and colored by daily activities and long-term strategies developed now and used to better inform our future.

Geography

Over millions of years, the Great Lakes region has been carved out by glaciers. Repeated glaciations scoured the landscape, creating huge basins that would later be filled with freshwater and become collectively known as the Great Lakes. Lakes Superior, Michigan, Huron, Erie, and Ontario combined have an estimated surface area of 95,000 square miles and hold roughly 90% of the U.S. supply of liquid freshwater. For perspective, the entire volume of the Great Lakes, six quadrillion gallons, is enough water to flood North America to an average depth of one meter.⁴

Today, the thousands of small, networked streams and lakes that are scattered throughout the 770,000 km² drainage basin feed the five Great Lakes with freshwater. In sum, the entire Great Lakes drainage basin is roughly two times the size of the Great Lakes themselves, resulting in relatively long water retention times of a minimum of 2.6 years for Lake Erie to a maximum of 191 years for Lake Superior.⁵ Water levels in the region fluctuate due to extraction, precipitation, evaporation, and outflow to the ocean through a series of canals via the St. Lawrence Seaway. The Great Lakes are integrators of change in the upland freshwater ecosystems and surrounding areas; as a result, the Great Lakes are relatively slow to respond to short-term change, but, conversely, once a change is initiated, it is difficult to slow its momentum.

Climate

Owing to its mid-continent location, far away from the moderating effects of the ocean and with an absence of any significant mountain barriers, the Great Lakes region typically experiences large swings in seasonal temperatures. During winter, cooler temperatures average around -9°C and stormy, windy, and snowy conditions arrive as air from the Arctic descends south; springtime temperatures average around 5°C⁶; in summer, warmer temperatures and humid conditions arrive when the subtropical Atlantic forces warm, humid air into the region.⁷ Summer in the Great Lakes region tends to be the rainiest season with short-lived but intense thunderstorms and rainfall.

⁴ McBean, E. & H. Motiee. (2008). Assessment of impacts of climate change on water resources: a long term analysis of the Great Lakes of North America. *Hydrol. Earth Syst. Sci.* 12: 239-255.

⁵ *Ibid.*

⁶ Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shutter, M.M. Wander, D.J. Wuebbles, D.R. Zak, R.L. Lindroth, S.C. Moser, & M.L. Wilson. (2003). Confronting climate change in the Great Lakes region: Impacts on our communities and ecosystems. Union of Concerned Scientists, Cambridge, MA, and Ecological Society of America, Washington, D.C. <http://www.ucsusa.org/greatlakes/glchallengereport.html>

⁷ Mishra, V., K.A. Cherkauer, & L.C. Bowling. (2011). Changing thermal dynamics of lakes in the Great Lakes region: Role of ice cover feedbacks. *Global and Planetary Change* 75: 155-172.

Terrain

The diverse landscapes bordering the Great Lakes range from forested shores, marshes and wetlands, and prairie lands, to metropolitan cities. The U.S. portion of the Great Lakes basin can be divided into two ecoprovinces of nearly equal size – a Laurentian Mixed Forest is primarily found in the northwestern portion of the basin and an Eastern Broadleaf Forest is found in the southeast.⁸ Much of the land in the southern portion of the Great Lakes region has been highly modified during the past two centuries to support agricultural interests and the development of large urban and suburban areas. It has been estimated that conversion rates of undeveloped lands to modified landscapes in Illinois has rivaled or outpaced any tropical deforestation rates witnessed in recent decades.^{9,10}

Economy

The Great Lakes regional economy is dominated by agriculture, shipping, fisheries, and tourism and recreation. During the last glacial recession 9,000 years ago, large quantities of sediments and fertile soils were deposited by the glaciers throughout the basin. Today, the northern portion of the Great Lakes remains largely forested but the southern region has experienced metropolitan and agricultural development. The agricultural industry grosses an estimated \$15 billion dollars annually, accounting for seven percent of total U.S. production and 25% of Canadian production.^{11,12} Water diversions and withdrawals for agricultural needs will likely increase as climate-driven changes in temperature and precipitation patterns increase.

One of the other major industries for the Great Lakes is shipping and cargo transport along the 1,270-mile long Great Lakes-St. Lawrence Seaway. This seaway connects the Great Lakes to the Atlantic Ocean through a series of manmade canals and locks. Bulk cargo carriers, ocean-going vessels, and smaller cruise ships can all safely transit the St. Lawrence Seaway, stopping at any of the 15 major international ports or 50 of the smaller regional ports. Approximately two billion tons of commercial shipping – mostly iron ore, coal, grain, or steel – passes through the St. Lawrence Seaway annually.¹³ Shipping and its associated industries support more than 225,000 jobs and gross an average of more than \$35 billion per year for the region.¹⁴ Lake level changes are therefore one of the most important concerns for regional managers. Future water levels will affect shipping canals, ports, and shoreline development, as well as residential water supply and quality.

⁸ Bailey, R.G. (1989). Explanatory supplement to the ecoregions map of the continents. *Envir. Conserv.* 15: 307-309.

⁹ Iverson, L.R. (1988). Land-use changes in Illinois, USA: the influence of landscape attributes on current and historic use. *Landscape Ecol.* 2: 45-61.

¹⁰ Iverson, L.R. (1991). Forest resources of Illinois: what do we have and what are they doing for us? In: Page, L.M., and M.R. Jeffords (eds). *Our Living Heritage: The Biological Resources of Illinois*. *Ill. Nat. Hist. Surv. Bull.* 34: 361-374. Champaign, IL.

¹¹ Great Lakes Protection Fund. Agriculture in the Great Lakes. www.glpf.org/ideas-in-action/agriculture-in-the-great-lakes

¹² EPA Great Lakes Basic Information www.epa.gov/glnpo/basicinfo.html

¹³ Quinn, F. (2002). *The Potential Impacts of Climate Change on Great Lakes Transportation*. The Potential Impacts of Climate Change on Transportation: Workshop Summary and Proceedings. October 1-2, 2002. U.S. Department of Transportation.

<http://climate.dot.gov/publications/workshop1002/quinn.pdf>

¹⁴ Marine Delivers. Economic Impact of Great Lakes Shipping www.marinedelivers.com/economic-impact-great-lakes-shipping

Commercial and recreational fisheries are important in the Great Lakes. Commercial fisheries generated approximately \$17.8 million in 2010¹⁵ and the recreational industry generates around \$4 billion annually.¹⁶ Species and habitats are at risk from changes in temperature and precipitation patterns, as well as changes in lake level and pH and the introduction of invasive and non-native species (some of which have been introduced to enhance the recreational industry¹⁷).

Compounding stressors

The impacts of climate change have the potential to amplify and counteract existing environmental stressors in the Great Lakes region, potentially undermining environmental advances made to protect lake conditions. Danz et al. (2007)¹⁸ attempted to systematically isolate the key environmental stressors in the Great Lakes basin using a principle component analysis methodology. Stressors were classified into one of the following categories – agriculture, atmospheric deposition, human population, land cover, or point source pollution – and compared using a multi-variate approach. The key stressor from agriculture was identified to be related to nitrogen, phosphorus, and herbicide application and subsequent runoff; atmospheric deposition was related to chloride, sulfate, nitrate, sodium, and inorganic nitrogen deposition; human population stressors were most related to population density, road density, and proportion of developed land; land cover stressors were most related to the amount of non-native landscapes (i.e. agricultural land, grazing land, urban development); and point source pollution was most related to overall discharge of chemical pollutants from point sources of wastewater.¹⁹ The Great Lakes have also been polluted over the past 200 years with mercury deposited from the burning of fossil fuels, waste incineration, chlorine production, and mining²⁰; elevated mercury levels have been detected in the pelagic food web.²¹

In addition, human alterations to the landscape, such as dams, levees, water diversions for agriculture and development, and removal or destruction of vegetation in coastal and riparian zones, all combine to decrease the resilience of freshwater systems. The impacts of climate change will act as another layer of stress to systems in the Great Lakes region. Biological assemblages will also be subjected to multiple stressors and may become more sensitive to cumulative stress over time as climate change impacts become more prevalent.

¹⁵ National Oceanic and Atmospheric Administration (NOAA). Fisheries Statistics Division. <http://www.st.nmfs.noaa.gov/st1/>

¹⁶ NOAA Great Lakes Environmental Research Laboratory (GLERL). Great Lakes Basin Facts. www.glerl.noaa.gov/pr/ourlakes/facts.html

¹⁷ NOAA GLERL. Great Lakes Economy. <http://www.glerl.noaa.gov/pr/ourlakes/economy.html>

¹⁸ Danz, N.P., G.J. Niemi, R.R. Regal, T. Hollenhorst, L.B. Johnson, J.M. Hanowski, R.P. Axler, J.J.H. Ciborowski, T. Hrabik, V.J. Brady, J.F. Kelly, J.A. Morrice, J.C. Brazner, R.W. Howe, C.A. Johnston, & G.E. Host. (2007). Integrated Measures of Anthropogenic Stress in the U.S. Great Lakes Basin. *Environ. Manage* 39:631-647.

¹⁹ *Ibid.*

²⁰ Evers, D.C., J.G. Wiener, C.T. Driscoll, D.A. Gay, N. Basu, B.A. Monson, K.F. Lambert, H.A. Morrison, J.T. Morgan, K.A. Williams, & A.G. Soehl. (2011). Great Lakes Mercury Connections: The Extent and Effects of Mercury Pollution in the Great Lakes Region. Biodiversity Research Institute. Gorham, Maine. Report BRI 2011-18.

²¹ Rolfhus, K.R., B.D. Hall, B.A. Monson, M.J. Paterson, & J.D. Jeremiason. (2011). Assessment of mercury bioaccumulation within the pelagic food web of lakes in the western Great Lakes region. *Ecotoxicology* 20:1520-1529.

Air Temperature

The Great Lakes region has a humid continental climate, characterized by large variations in temperatures driven by air masses from the Arctic, Pacific, and Gulf of Mexico.²² The Great Lakes themselves moderate seasonal temperatures to some degree but do not have as large of an effect as do the oceans along the Atlantic, Pacific, and Gulf coasts. That said, along the lakeshores, the water bodies act to absorb heat in summers and radiate heat during winters. This works to buffer extreme temperatures relative to locations further inland, away from the moderating effects of the lakes.

Since 1900, instruments indicate that on average, the climate in the Great Lakes region has been relatively stable. While the climate, defined as the average of long-term variations in weather, has been stable over the past century, there has been a high degree of interannual variability; annual temperatures can regularly flux by up to -15°C from the long-term mean.²³ However, over the past few decades, average temperatures have been increasing relative to historical norms, especially in the winter.²⁴

Most temperature observations around the Great Lakes region evidence a general, regionwide warming trend since the 1950s. Average temperatures in Chicago have increased by 0.25°C per decade from 1945-2009.²⁵ Across all of Illinois, average temperatures have increased by 0.16°C per decade. Average annual temperatures in Minnesota have increased by 0.27°C per decade.²⁶ Over the coming century, temperatures are expected to continue to increase throughout the Great Lakes region due to anthropogenic climate change. By 2100, computer ensemble models indicate that average temperatures could increase by an estimated $1.5\text{--}7^{\circ}\text{C}$ depending upon the emissions scenario applied.²⁷ The projected temperatures are a direct function of greenhouse gas emissions; higher emissions equate to higher temperatures.

Rates of temperature change will vary with seasons and geographic location. Initially, temperature increases are projected to be most apparent for winter months in the more northerly states. Currently in the Northeast United States, wintertime temperatures are rising twice the rate of the annual average.²⁸ After the middle of the century, however, models indicate that temperature increases will be greater during summer in the more southerly states such as Illinois and Indiana. By the end of the century, mean wintertime temperatures are projected to rise by $2\text{--}4^{\circ}\text{C}$ and the

²² Government of Canada - Toronto, Ontario and United States Environmental Protection Agency - Great Lakes National Program Office. (1995). *The Great Lakes: An Environmental Atlas and Resource Book*. Third Edition, Chicago, Illinois.

<http://www.epa.gov/glnpo/atlas/index.html>

²³ Kling et al. 2003

²⁴ Wuebbles, D.J., K. Hayhoe, & J. Parzen. (2010). Introduction: Assessing the effects of climate change on Chicago and the Great Lakes. *Journal of Great Lakes Research* 36: 1-6.

²⁵ Hayhoe, K., J. VanDorn, T. Croley II, N. Schlegal, & D. Wuebbles. (2010a). Regional climate change projections for Chicago and the US Great Lakes. *Journal of Great Lakes Research* 36: 7-21.

²⁶ NCDC Climate at a Glance in Hayhoe et al. 2010a

²⁷ Angel, J.R. & K.E. Kunkel. (2010). The response of Great Lakes water levels to future climate scenarios with an emphasis on Lake Michigan-Huron. *Journal of Great Lakes Research* 36: 51-58.

²⁸ Hayhoe, K., C. Wake, T. Huntington, L. Luo, M. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. DeGaetano, T. Troy, & D. Wolfe. (2006). Past and future changes in climate and hydrological indicators in the U.S. Northeast. *Climate Dynamics* 28: 381-407.

temperature of the coldest day of the year is projected to warm by 4-8°C. The number of frost days per year will be significantly decreased and the date of the last frost will be 20-30 days earlier than historic norms. Summers will experience an increase in the frequency, duration, and intensity of heat waves. Some models indicate that heat waves could occur every other year to several each summer. The number of hot days over 32.2°C will increase and there will be a larger proportion of extremely hot days with temperatures over 37.8°C by the end of the century.

One way scientists have been envisioning the future is by projecting “climate migrations” of states and cities.²⁹ To do this analysis, a city/state’s current climate conditions are quantified and classified using historic data. Then, using global climate models, scientists identify regions where the climate is projected to mimic a given city/state’s conditions. Therefore it would appear that the city/state’s climate has ‘migrated’ due to climate change. The Union of Concerned Scientists has an interactive Migrating Climates feature on its website; for example, by the end of the century, Illinois summers will become more like those in present-day Texas and Indiana winters will feel more like those in present-day Washington, D.C./Virginia.³⁰

Secondary impacts

- Increased frequency, duration, and intensity of heat waves: A warmer future will naturally lend itself to having a higher frequency of heat waves. In the future, hot days will generally feel hotter due to an increase in humidity. By the end of the century, heat waves could occur approximately three times each year under higher emissions scenarios.³¹ From 1961-1990, Chicago experienced an average heat wave season length of 68.6 days; in the future, the season could extend to 108.0/137.7 days under low/high emissions scenarios.³²
- Reduced air quality: Models indicate that summer weather patterns could arrive earlier and last longer in the Great Lakes region. The more intense and extended heat could cause an increase in ground level ozone of 10-25% and particulate matter. This would cause regional air quality to decrease and affect incidence of respiratory illness and disease.³³
- Longer growing season: Warmer temperatures will increase the length of the growing season mainly due to earlier dates from the last spring frost and later dates for the first fall freeze. It has been estimated that across the Northern Hemisphere, growing seasons have advanced by one to 1.5 days per decade during the past 50 years.³⁴ Also, more CO₂ availability in the atmosphere may stimulate growth rates of plants but other nutrients, such as nitrogen, may become limiting factors.

²⁹ Kling et al. 2003

³⁰ Union of Concerned Scientists. Migrating Climates. http://www.ucsusa.org/greatlakes/winmigrating/glwinmig_intro.html

³¹ Hayhoe, K., S. Sheridan, L. Kalkstein, & S. Greene. (2010b). Climate change, heat waves, and mortality projections for Chicago. *Journal of Great Lakes Research* 36:65-73.

³² Vavrus. S. & J.V. Dorn. (2010). Projected future temperature and precipitation extremes in Chicago. *Journal of Great Lakes Research* 36: 22-32.

³³ Lin, J.-T., D.J. Wuebbles, H.-C. Huang, Z. Tao, M. Caughey, X.-Z.Liang, J.-H.Zhu, & T. Holloway. (2010). Potential effects of climate and emissions changes on surface ozone in the Chicago area. *Journal of Great Lakes Research* 36 (Supplement 2). 59-64.

³⁴ Schwartz, M.D., R. Ahas, & A. Aasa. (2006). Onset of spring starting earlier across the Northern Hemisphere. *Glob. Change Biol.* 12: 343-351.

- Increased agricultural pests: Warmer winters and warmer, drier summers could increase growth rates and wintertime survival of known agricultural pests. For example, the gypsy moth, a generalist defoliator, may experience increased survival rates during warm winters, enabling population sizes to overwinter and increase.³⁵
- Increased invasives establishment: Many plants and animals will adapt to warmer than normal water and air temperatures. In some cases, an increase in temperature may make some invasive species more aggressive, causing current invasive species to expand their geographic spread and population size. Further, new invasive species can be opportunistic, thriving where landscapes have been altered or disturbed. Climate change will stress many native plants and animals, providing a window within which invasive species may establish themselves.³⁶
- Shifting landscapes: Many plants and animals have preferred thermal regimes that coincide with their historic ranges. As air temperatures rise due to climate change, plants and animals may exhibit a northward movement from their historic ranges. However, the predicted rates of change may exceed some species' natural rates of migration or habitat fragmentation may prevent the ability of some animals and plants to migrate. Climate change may therefore cause some species to die off in regions in which they are currently found and, without active management, may not relocate to more tolerant thermal regimes.
- Shifting zones: Shifts in plant hardiness zones, a metric based on the average annual minimum temperature in which a plant species can be cultivated, are expected to migrate northward.³⁷ By the end of the century, the Chicago region is expected to have a plant hardiness zone similar to current day conditions in Southern Illinois under a low emissions scenario or Northern Alabama under a high emissions scenario. This will have implications for the nearly 100 tree species and shrubs found within the region. The new plant hardiness zones may be unsuitable for regionally important species such as the northern red oak, black cherry, white oak, sugar maple, and red maple. Instead, the habitat may become more suitable for silver maple, bur oak, post oak, sweetfum, Kentucky coffee tree, black hickory and wild plum.^{38,39} The establishment of novel plants will alter the region's landscape ecology and biology.
- Shifts in phenology: Phenology refers to the general timing of natural events; the timing of tree budding and butterfly migrations are well known indicators of phenology. In Sauk County, Wisconsin, a 65-year long record of 55 different seasonal events started by Aldo Leopold indicates that 19 of the 55 processes recorded have steadily occurred earlier in the

³⁵ Williams, R.S., D.E. Lincoln, & R.J. Norby. (2003). Development of gypsy moth larvae feeding on red maple saplings at elevated CO₂ and temperature. *Oecologia* 137: 114-122.

³⁶ Hellmann, J.J., K.J. Nadelhoffer, L.R. Iverson, L.F. Ziska, S.N. Matthews, P. Myers, A.M. Prasad, & M.P. Peters. (2010). Climate change impacts on terrestrial ecosystems in metropolitan Chicago and its surrounding, multi-state region. *Journal of Great Lakes Research* 36: 74-85.

³⁷ Hellmann et al. 2010

³⁸ Iverson, L.R., A.M. Prasad, S.N. Matthews, & M. Peters. (2008). Estimating potential habitat for 134 eastern US tree species under six climate scenarios. *For. Ecol. Manag.* 254: 390-406.

³⁹ Prasad, A.M., L.F. Iverson, S. Matthews, & M. Peters. (2007-ongoing). A climate change atlas for 134 forest tree species of the Eastern United States [database]. <http://www.nrs.fs.fed.us/atlas> Northern Research Station, USDA Forest Service, Delaware, Ohio.

region since the 1930s.⁴⁰ As the rhythms of nature respond to the changing climate, there will be unforeseen consequences to existing trophic structures. For example, if the timing of insect emergence and migratory bird patterns no longer overlap, the region could experience an increase in pests due to the absence of a top-down predator control on insect populations. This explosion of pests may adversely affect agriculture, natural ecosystems, and urban heat islands.

Lake Temperature and Ice Cover

The large volume of the Great Lakes translates into a tremendous capacity to store and retain heat. Future warming air temperatures will lead to warmer lake temperatures, altering heating capacities, water circulation patterns, wintertime ice area, and summertime stratification.⁴¹ Lake temperatures are expected to warm earlier in the spring, reach higher maximum summer temperatures, and cool more slowly in the fall. From 1979 to 2006, summertime surface water temperatures increased by approximately 2.5°C.⁴² Warmer water temperatures coupled with warmer air temperatures will reduce the duration, thickness, and extent of the annual ice cover on the lakes.

Lake ice cover is a sensitive indicator of regional climate and can vary dramatically between years. In 1979 an estimated 95% of the Great Lakes was covered with ice while in 2002, only 11% was covered.⁴³ Typically, ice will begin to form on the lakes in late November to early December and maximum ice extent is reached in early February to March; lakes will often be ice free by late May to early June. Since the 1970s, annual ice cover on the Great Lakes has been declining and in 2010, there was an average of 71% less ice coverage relative to 1973.⁴⁴ Shallow lakes are, in general, more sensitive to climate fluctuations because of their reduced water heat capacity relative to deep-water lakes; the shallower lakes (e.g., Huron and Erie) will respond more quickly to changes in climate than the deeper lakes (e.g., Superior, Michigan, and Ontario). If trends of reduced ice coverage continue, large lakes such as Lake Michigan could experience ice-free winters as early as 2020.⁴⁵

Secondary impacts

- Algal blooms: Increased water temperatures, reduced ice cover, and increased nutrients from runoff could stimulate cellular growth of filamentous algae along the shorelines of the lakes. The algae are visually unappealing, appearing like slime, and can harbor and produce pathogens. Some bloom-forming algae species can release volatile toxins, causing respiratory irritation in animals and people. Further, once an algal bloom terminates, bacteria consume the algae causing localized zones with diminished concentrations of dissolved oxygen that can cause fish mortality.

⁴⁰ Bradley, N.L., A.B. Leopold, J. Ross, & W. Huffaker. (1999). Phenological changes reflect climate change in Wisconsin. *Proc. Natl. Acad. Sci.* 96: 9701-9704.

⁴¹ Government of Canada - Toronto, Ontario and U.S. EPA - Great Lakes National Program Office 1995

⁴² Austin & Colman 2007 in Wang, J., X. Bai, H. Hu, A. Clites, M. Colton, & B. Lofgren. (2012). Temporal and spatial variability of Great Lakes ice cover, 1973-2010. *Journal of Climate* 25: 1318-1329.

⁴³ Wang et al. 2012

⁴⁴ *Ibid*

⁴⁵ Hayhoe et al. 2010a

- Increased lake stratification: Historically, lakes in the Great Lakes region “turned over” during shifts of season, bringing nutrient-rich but oxygen-depleted waters to the surface and shuttling oxygen-rich, nutrient-poor waters to depth. Increasing the thermal capacity and heat storage in lakes will reduce seasonal mixing and increase stratification. Therefore, mixing and oxygen levels may decrease in response to regional warming trends.^{46,47}
- Reduced primary productivity: A warmer lake surface will serve to enhance the water stratification that occurs seasonally in the spring and summer.⁴⁸ A more stratified water column limits the amount of water exchange and nutrient mixing with the deep. Therefore, the reduced access to nutrients could limit primary production, having cascading consequences for higher trophic levels due to a lack of food.
- Increased hypoxia: Primary producers create oxygen as a natural byproduct of photosynthesis. Reduced primary production will also translate to less available oxygen in the water column, which could negatively affect zooplankton and fish. Also, warmer waters cannot hold as much gas as colder water; as lakes warm, they will physically hold less oxygen relative to historical norms.⁴⁹
- Altered fisheries: Fish have preferred thermal regimes; as lake temperatures change, fish distribution will be altered as fish seek out thermal refugia. Further, increased storm disturbance without ice protection could increase fish egg mortality. However, a reduction in annual ice cover will reduce the severity and duration of wintertime oxygen depletion in the waters of the Great Lakes, reducing seasonal winterkill of fish populations.⁵⁰
- Longer shipping season: From the 1950s to 1995, ice made the waters of the Great Lakes non-navigable for 11-16 weeks each winter by blocking navigation lanes, ports, and locks in the system. Warmer water and air temperatures will likely reduce the ice cover by one to three months, extending the shipping season.⁵¹
- Increased shoreline erosion: Wintertime ice shields the shoreline from the effects of storms and winds. As ice cover is reduced, shoreline erosion rates could increase, causing a subsequent decrease in water quality as more sediments are suspended in the water column.
- Shifts in phenology: Warmer water temperatures can increase maturation and growth rates of some plants and animals. Increased growth rates will cause some animals, like insects, to emerge earlier in the year relative to historical norms. If some animals, like insects, respond disproportionately to changes in water temperature as compared to their predators, climate change could cause a decoupling within food chains. This would have cascading consequences throughout the entire food web of the Great Lakes, altering productivity patterns and trophic structures.

⁴⁶ Mishra et al. 2011

⁴⁷ Trumpickas, J., B.J. Shuter, & C.K. Minns. (2009). Forecasting impacts of climate change on Great Lakes surface water temperatures. *Journal of Great Lakes Research* 35: 454-463.

⁴⁸ Government of Canada - Toronto, Ontario and U.S. EPA - Great Lakes National Program Office 1995

⁴⁹ Committee on Environment and Natural Resources 2010

⁵⁰ Kling et al. 2003

⁵¹ Quinn 2002

Precipitation

One of the major impacts of climate change will be alterations of the hydrologic cycle, but most global climate models have difficulty estimating future changes in precipitation patterns and rainfall intensities. In general, forecasted precipitation trends for the Great Lakes region are similar regardless of the emissions scenario input. By the end of the century, most models indicate an increase of up to 20% in annual precipitation across the Great Lakes region⁵² but published ranges have varied from a five cm decrease to a 20 cm increase in annual precipitation.⁵³ Most likely, the Great Lakes region will experience wetter than average conditions by 2100.

The seasonality and form of precipitation is expected to be altered by climate change. In the future, more precipitation is expected to fall in the form of rain and less as snow. Since 1980, almost 75% of the winters have seen below historical averages for snowfall.⁵⁴ Over the next few decades, the more southerly states could lose between two to four snow days each year. By the end of the century, the entire Great Lakes region could have 30-60% fewer snow days annually depending on the emissions scenario.⁵⁵ In addition, models project a shift in timing of precipitation from summer to spring.⁵⁶

In the future, more precipitation is expected to fall as rain and in heavy downpours, particularly during winter and spring seasons. Warmer air can hold more water vapor, therefore precipitation events are expected to become more intense and frequent. Heavy downpours, defined as the 10% largest amount of rainfall over a 24-hour period, are now twice as frequent as they were a century ago.⁵⁷ An increase in intense rainfall will increase the likelihood of flooding across the Midwest as precipitation patterns directly influence regional runoff and stream flow.

Secondary impacts

- **Increased flood risk:** More intense but less frequent rainfall could enhance flooding regionally. Landscapes will not be able to absorb the waters from a deluge, causing flooding after intense rainstorms. Existing municipal stormwater infrastructure may be overwhelmed during periods of heavy rain, causing increased combined sewer overflows.
- **Increased runoff and erosion rates:** Rainfall generates surface runoff when it falls upon impervious surfaces or soils that are already saturated with water. More intense rainstorms could enhance surface runoff, causing localized erosion as dislodged sediments and topsoil become suspended in the runoff water. As runoff waters flow over various surfaces, chemicals, pollutants, sediments, and nutrients will be transported and deposited into regional streams and rivers, which may degrade water quality and enhance algae blooms.

⁵² Hayhoe et al. 2010a

⁵³ Angel & Kunkel 2010

⁵⁴ Hayhoe et al. 2010a

⁵⁵ *Ibid*

⁵⁶ Cherkauer, K.A. & T. Sinha. (2010). Hydrologic impacts of projected future climate change in the Lake Michigan region. *Journal of Great Lakes Research* 36: 33-50.

⁵⁷ Changnon, S.A. & K.E. Kunkel. (2006). Severe storms in the Midwest. Informational/Educational Material 2006-06. Illinois State Water Survey. Champaign, IL. 74 pp.

- Increased stream flow: Precipitation runoff supplies roughly 50% of the freshwater stored in the Great Lakes. Water is delivered to the lakes through a vast network of streams and rivers found throughout the drainage basin. On average, annual total runoff is expected to increase by up to 7-9% across all future emissions scenarios. Maximum seasonal runoff is expected to occur in the winter and spring and will have increased average runoff by 20-60%. Winter and spring will experience an increase in the number of days with high flows, autumn will experience more low-flow days, and summer will have a varied response.⁵⁸
- Soil moisture: Warmer summertime weather and increased transpiration coupled with altered precipitation frequency, intensity, and duration could lower summertime soil moisture levels. This will affect agricultural production as well as precipitation runoff generation throughout the year.⁵⁹

Lake Levels

It is difficult for scientists to accurately predict the impact climate change will have on lake levels because water level is a complex balance between riverine input and output, precipitation and evaporation, wind, humidity, and extraction rates. All of these variables will respond to climate change to some unknowable extent; lake level is the integrated consequence of these variables interacting with and counteracting against each other. As a result, lake levels will be in flux for centuries to millennia as the many facets of climate change and the human response play out.

There have been disparate lake level results from varying global climate model runs. Some have predicted large drops in lake levels (up to 1.4 m) due to increased evaporation rates as temperatures rise, while others have displayed slight increases in lake level (up to 0.35 m) because of increased precipitation patterns. One study analyzed the results of 565 model simulations from 23 different global climate models in the hopes that the ensemble forecast would provide the most probabilistic future.⁶⁰ The results indicated that lake levels are most sensitive to changes in temperature but there is still a high degree of variability within emissions scenarios. Under a low emissions future, lake levels could range from -0.87 - + 0.31 m and under a high emissions future, lake levels could range from -1.81 - +0.88 m by the year 2100. Models project that Lake Superior's water level will respond the least to changes in climate. The water levels of Lakes Michigan, Huron, Erie, and Ontario are projected to respond similarly to changes in climate. Despite having a large range of uncertainty regarding future lake levels, most of the 23 models predict a decrease in lake level with time due to climate change; the magnitude of the decline is dictated by the intensity of future emissions.⁶¹

Secondary impacts

- Reduced shipping capacity: The St. Lawrence Seaway was developed in the late 1950s and constructed with an ideal of stable lake levels. The U.S. government maintains a 27-foot

⁵⁸ Cherkauer & Sinha 2010

⁵⁹ *Ibid*

⁶⁰ Angel & Kunkel 2010

⁶¹ *Ibid*

depth below low water datum (LWD) in the St. Marys, St. Clair, and Detroit rivers as well as in Lake St. Clair and some of the Great Lakes ports.⁶² Shipping interests have therefore become dependent on relatively stable lake levels. Increased evaporation rates due to warmer temperatures may lower lake water levels. By 2030, lake levels may be above the LWD for Lake Ontario and at the LWD for Lake Erie. If the lake level is lower, it is estimated that every one inch in lake level drop will cause a 1,000 foot ship to lose 270 tons of cargo capacity; an ocean-going vessel of about 740 feet will lose 100 tons of capacity.⁶³

- Reduced hydropower: Decreased water levels will reduce the amount of water available to generate power through hydroelectric dams for the region.
- Reduced wetland areas: Due to urban development, land use change, and channelizing of streams, areas historically occupied by marshes, wetlands, and swamps have diminished over time in the Great Lakes region. In the future, lower lake water levels will cause existing wetlands to be further reduced; at the same time, new habitat that was formerly submerged will be opened up as water levels drop.⁶⁴
- Water supply: It is anticipated that water demands will be 20-50% higher in the future as population and economic requirements grow.⁶⁵ The Great Lakes serve as important natural reservoirs of freshwater for the region. If water levels decline as a result of climate change, the total volume of freshwater available will decline as well, which could complicate existing infrastructure for municipalities. This will likely not become a major concern for the region because water intake pipes are located at relatively deep depths in the Great Lakes; for example, in Lake Michigan most water supply intake pipes are located between 900 to 1500 m offshore so there should be no direct impacts from lower lake levels.⁶⁶
- Loss of shoreline: If lake levels increase due to changes in climate, the region could witness an increase in the surface area of the Great Lakes as waters rise. Higher lake levels would cause a loss of land and shoreline, potentially compromising buildings and infrastructure built adjacent to the lakes.

Water Chemistry

The potential consequences of enhanced diffusion of CO₂ into the waters of the Great Lakes has not been evaluated in any systematic fashion. Ocean acidification, or the drop in pH seen when CO₂ reacts with naturally occurring carbonate and bicarbonate ions in water, has been reported to cause a 0.002 per year decrease in pH in the open ocean. However, the chemistry of the Great Lakes is much different from that of the open ocean, making it harder to assess and predict changes in water chemistry due to climate change. Further, the Great Lakes integrate more variables than the open ocean, such as nutrient loading from agriculture and urban runoff, adding spatial and temporal complexity to predicting changes in water chemistry.

⁶² Quinn 2002

⁶³ *Ibid*

⁶⁴ Kling et al. 2003

⁶⁵ Dziegielewski, B. (2008). Regional water demand scenarios for northeastern Illinois: 2005-2050. Project Completion Report prepared for the Chicago Metropolitan Agency for Planning (CMAP).

⁶⁶ Angel & Kunkel 2010

The Great Lakes are on average slightly basic with pH values ranging from 8.0 to 8.35 from 1983-2009.⁶⁷ When compared to the ocean, the Great Lakes have a lower buffering capacity against pH changes because they have a lower alkalinity. Alkalinity measures the ability of water to neutralize acids such as carbonic acid, a byproduct of CO₂ dissolution into aqueous solution. The more alkaline a solution is, the more acid it can absorb without dramatically altering the pH. The average alkalinity of the Great Lakes ranges from 36% in Lake Superior to 95% in Lake Michigan relative to surface ocean alkalinity.⁶⁸ Because of the lower alkalinity, the Great Lakes are predicted to respond more to changes in atmospheric CO₂ than will the ocean. By 2090, under the Intergovernmental Panel on Climate Change (IPCC) emissions scenario A2, the pH of the Great Lakes may decline by 0.30 pH units, which represents a pH decrease of 0.004 per year, a rate twice that of the ocean.⁶⁹

However, the Great Lakes differ from the ocean in many important ways that can affect pH. First, the deposition of acidic nitrogen and sulfur from the atmosphere or through agricultural and urban runoff can increase acidification by 10-50% or more over acidification rates expected from fossil fuel emissions alone. Second, in the fall and spring, the Great Lakes are relatively well mixed, meaning that lower pH surface waters will mix with the deeper waters in the Great Lakes serving to acidify the waters at depth. However, under stratified conditions in the summer and winter, the deeper waters of the Great Lakes naturally store CO₂ produced by respiration; the CO₂ is “vented” to the atmosphere during the mixing events of spring and fall. Net CO₂ uptake and acidification rates of the Great Lakes will be a function of physical processes (mixing, temperature) and biological rates (photosynthesis, respiration). Most of these processes have not been well quantified, making it difficult to accurately predict net effects.

Relative to other freshwater lakes and rivers, the Great Lakes have a higher buffering capacity because of the surrounding geological terrain. All of the Great Lakes except Lake Superior contain a lot of carbonate rock, such as limestone and dolomite, in their drainage basin. Runoff from drainage basins with a high proportion of carbonate rock has a higher alkalinity than runoff from non-carbonate rock, such as granite and sandstone.⁷⁰

In sum, the changes in water chemistry of the Great Lakes will not follow trends in either the open ocean or in smaller lakes and streams. This heightens the need to study and improve our understanding of the Great Lakes’ biogeochemical cycles in order to predict how increased fossil fuel emissions may affect water chemistry.

⁶⁷ NOAA Ocean Acidification Steering Committee. (2010). NOAA Ocean and Great Lakes Acidification Research Plan, NOAA Special Report, 143 pp.

⁶⁸ *Ibid*

⁶⁹ *Ibid*

⁷⁰ *Ibid*

Secondary impacts

- Reduced calcification rates: As pH drops, the saturation states for aragonite and calcite, two forms of calcium carbonate, will decrease. This decreased saturation state means that it could be more energetically costly for calcifying animals, such as the zebra mussel, to biosynthesize their shell. The responses of zebra mussels and other calcifying animals in the Great Lakes needs to be further studied to determine physiological tolerances of native and non-native calcifying species to changes in pH.
- Non-linear biological responses: In general, freshwater plants and animals are thought to be more tolerant to slight changes in pH relative to oceanic plants and animals because of their evolutionarily derived adaptations to the highly variable conditions that can be naturally experienced in freshwater ecosystems. However, in a whole-lake acidification experiment in Wisconsin, when pH was systematically lowered from 6.1 to 4.7, monitored animal populations revealed non-linear responses to linear changes. Some animal populations, such as *Daphnia*, exhibited immediate declines, while other fish populations, such as yellow perch, increased but later decreased in population size.⁷¹ As yet, it is unknown how animal and plant populations in the Great Lakes will respond to changes in pH but there are sure to be some unexpected surprises.

⁷¹ Stow, C.A., S.R. Carpenter, K.E. Webster, & T.M. Frost. (1998). Long-term environmental monitoring: Some perspectives from lakes. *Ecol. App.* 8: 269–276.

Adaptation Projects and Programs in the Great Lakes Region

Climate change is a global problem that requires the development and implementation of robust management strategies that can help practitioners prepare for and respond to impacts. For the purposes of this report, we use the IPCC definition of adaptation – an “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.”⁷² Adaptation actions are employed to avoid or take advantage of impacts either by decreasing vulnerability or increasing resilience.^{73,74} Approaches to adaptation include supporting resistance, resilience, or response of human and natural systems in the face of change. *Resistance* approaches include those actions that reduce the amount of change or increase the ability of systems to withstand change, while *resilience* approaches strive to improve the ability of systems to recover from change.⁷⁵ *Response* actions focus on helping systems accommodate any changes that do occur.⁷⁶ The challenge that climate change poses for practitioners is that the right answer at one time or place may not be the right answer at some other time or place; in fact, a whole range of options may be needed in order to limit the negative effects of climate change.

As adaptation theory and practice has gained traction over the last few years, literature has developed that examines guiding principles of adaptation; more exhaustive discussions may be found in other resources, such as those listed in Appendix A. Another useful resource is EcoAdapt’s Climate Adaptation Starter Kit, which is a primer containing resources, tools, and adaptation examples to support practitioners new to the field.⁷⁷

Adaptation Projects and Initiatives

This section presents examples and notable trends of over one hundred adaptation projects and initiatives throughout the Great Lakes region uncovered in this survey. We selected 57 projects to present as full case studies; more information on the methodology used is available in Appendix B and a list of the selected case studies grouped by adaptation strategy may be found in Appendix C. In addition, full case studies are available in Appendix D.⁷⁸

⁷² Intergovernmental Panel on Climate Change (IPCC). (2007). *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., et al. (eds.)] (Cambridge, UK: Cambridge University Press). 996 pp. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html.

⁷³ Pew Center. (2009). *Climate Change 101: Understanding and Responding to Global Climate Change*. Pew Center on Global Climate Change and the Pew Center on the States. <http://www.pewclimate.org/docUploads/Climate101-Complete-Jan09.pdf>.

⁷⁴ Hansen, L.J. & J.R. Hoffman. (2010). *Climate Savvy: Adapting Conservation and Resource Management to a Changing World*. Island Press, Washington, D.C.

⁷⁵ Gregg, R.M., L.J. Hansen, K.M. Feifel, J.L. Hitt, J.M. Kershner, A. Score, & J.R. Hoffman. (2011). *The State of Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas*. EcoAdapt, Bainbridge Island, WA. http://ecoadapt.org/data/library-documents/EcoAdapt_Marine%20and%20Coastal%20Synthesis%20Report_2011_Final.pdf

⁷⁶ Millar, C.I., N.L. Stephenson, & S.L. Stephens. (2007). Climate change and forests of the future: managing in the face of uncertainty. *Ecol. App.* 17(8): 2145-2151.

⁷⁷ EcoAdapt’s Climate Adaptation Starter Kit <http://ecoadapt.org/programs/awareness-to-action/climate-starter-kit>

⁷⁸ These case studies will also be available on the Climate Adaptation Knowledge Exchange (CAKE; www.cakex.org). Within the database on CAKE, users can search and cross-reference different adaptation projects in a variety of ways, including by adaptation strategy type, taxonomic/habitat/sectoral focus, funding source(s), targeted impacts, and more.

Climate change adaptation activities may be grouped in a number of ways.^{79,80,81} In order to organize our findings for this survey, we grouped adaptation strategies as they relate to freshwater (and in some cases, at the freshwater/terrestrial interface) by the following categories – *Capacity Building, Policy, Natural Resource Management and Conservation, and Infrastructure, Planning, and Development*. Examples from the natural and built environments as they relate to freshwater resources are examined in both *Capacity Building* and *Policy*. We then present examples from natural systems in *Natural Resource Management and Conservation* and those focused on the built environment in *Infrastructure, Planning, and Development*.

1. Capacity Building
 - a. Design or reform institutions
 - b. Conduct research, studies, and assessments
 - c. Conduct training and planning exercises
 - d. Increase/improve public awareness, education, and outreach efforts
 - e. Create/enhance resources and tools
 - f. Monitor climate change impacts and adaptation efficacy

2. Policy
 - a. Develop/implement adaptation plans
 - b. Create new or enhance existing policies or regulations
 - c. Develop/implement adaptive management strategies

3. Natural Resource Management and Conservation
 - a. Incorporate climate-smart guidelines into restoration
 - b. Enhance connectivity and areas under protection
 - c. Reduce local climate or related change
 - d. Reduce non-climate stressors likely to interact with climate change

4. Infrastructure, Planning, and Development
 - a. Make infrastructure resistant or resilient to climate change
 - b. Community planning (developing climate-smart communities)
 - c. Create or modify shoreline management measures
 - d. Develop disaster preparedness plans and policies

⁷⁹ Hansen, L. & J. Biringer. (2003). Building Resistance and Resilience to Climate Change. In: L.J. Hansen, J.L. Biringer, and J.R. Hoffman (eds.), *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems*. World Wildlife Fund, Berlin, Germany.

⁸⁰ Fischlin, A., G.F. Midgley, J.T. Price, R. Leemans, B. Gopal, C. Turley, M.D.A. Rounsevell, O.P. Dube, J. Tarazona, & A.A. Velichko. (2007). Ecosystems, their Properties, Goods, and Services. In: *Climate change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.). Cambridge, U.K. Cambridge University Press: 211-272.

⁸¹ Heinz Center. (2008). *Strategies for Managing the Effects of Climate Change on Wildlife and Ecosystems*. Washington, D.C.: The H. John Heinz III Center for Science, Economics and the Environment. 43p.

Capacity Building

Climate change adaptation is a developing field that requires a significant amount of capacity in order to move from theory to action. Practitioners are rarely trained to integrate climate change into their work through formal mechanisms, which has created both great need and opportunity. Building capacity of organizations, practitioners, and the public can increase the ability to plan, develop, and implement adaptation actions. Example strategies within this category include designing or reforming institutions to support resilience, conducting impacts and vulnerability assessments, investing in training and outreach efforts, and developing new tools and resources, among others. The majority of projects uncovered in our survey are focused on building capacity to address climate change.

Design or reform institutions

An important facet of capacity building as an adaptation strategy is ensuring that institutional support is sufficient and appropriate to address the widespread effects of global climate change at multiple scales. This strategy includes either creating new institutions or enhancing existing institutions by increasing organizational capacity and coordinating planning and management.

Create new institutions

This strategy includes creating new institutions, such as committees, working groups, or advisory bodies, that can develop, guide, and implement adaptation activities. At the federal level, action is being taken that may enhance adaptation efforts in the Great Lakes region. For example, the Interagency Climate Change Adaptation Task Force was created to provide national adaptation recommendations in order to support federal agency action. The Task Force created working groups to develop adaptation strategies related to different sectors.⁸² For example, the Water Resources Adaptation working group, comprised of federal representatives from the Department of Interior, Environmental Protection Agency (EPA), and the Council on Environmental Quality (CEQ), developed the 2011 *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*.⁸³ This plan includes six priority recommendations to improve and guide federally-coordinated freshwater conservation and management in light of climate change:

- Create a planning process for water resources management adaptation
- Improve information access to support decision making
- Assess vulnerability of water resources
- Improve water use efficiency
- Support Integrated Water Resources Management
- Increase training and outreach efforts.

⁸² Gregg, R. M. (2010). *Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force* [Case study on a project of the White House Council on Environmental Quality]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

⁸³ Interagency Climate Change Adaptation Task Force. (2011). *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*. Washington, DC: Interagency Climate Change Adaptation Task Force. http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf

This strategy is also being applied in multiple Great Lakes states and cities. In Wisconsin, Michigan, Pennsylvania, and the City of Chicago, working groups have been created to organize climate research and adaptation strategy development. The Wisconsin Initiative on Climate Change Impacts (WICCI) was created to support the efforts of multiple stakeholders charged with identifying vulnerabilities and developing adaptation strategies. WICCI is supported by a Science Council, an Operations and Outreach unit, an Advisory Committee, and Working Groups. The Working Groups were created to assess impacts on specific sectors or geographies and to develop adaptation recommendations; the groups include those focused on Adaptation, Agriculture, Central Sands Hydrology, Climate, Coastal Communities, Coldwater Fish and Fisheries, Forestry, Green Bay, Human Health, Milwaukee, Plants and Natural Communities, Soil Conservation, Stormwater, Water Resources, and Wildlife.⁸⁴ The Michigan Climate Coalition, a public-private partnership modeled after the WICCI, has also formed sector-specific subgroups that organize climate change activities, research, and initiatives around agriculture, coasts, education, energy, forests, health, inland waters, municipalities, planning, and wildlife. The Coalition organizes conferences and symposiums at an annual or more frequent basis to facilitate communication and information sharing between the working groups. The subgroups summarize and translate climate-related work being done on their particular sector, identify where there are gaps in knowledge, identify opportunities for collaboration, and work to bring together people that otherwise would not have an opportunity to connect.⁸⁵ The Pennsylvania Climate Change Advisory Committee created four sector-specific working groups to develop adaptation strategies; each group – Infrastructure, Public Health and Safety, Natural Resources, and Tourism and Outdoor Recreation – was led by two to three co-chairs representing governmental and non-governmental interests. The groups worked individually to identify sector-specific impacts and develop adaptation strategies.⁸⁶ Finally, the City of Chicago created an Adaptation Advisory Group to provide high-level aid and guidance for the city’s adaptation efforts, including implementation, monitoring success, and communications.⁸⁷

Non-governmental organizations have also been active in creating institutions to provide technical assistance and support for adaptation planning. The Center for Clean Air Policy created the Urban Leaders Adaptation Initiative in order to serve as a resource for local governments looking to develop and implement climate-resilient strategies dealing with land use and infrastructure; three cities in the Great Lakes are current partners, including Milwaukee (Wisconsin), Chicago (Illinois), and Toronto (Ontario).⁸⁸ In Quebec, Ouranos, a non-profit consortium of 400 scientists and other practitioners, was created to support the “[acquisition] and [development of] knowledge on climate

⁸⁴ Gregg, R. M. (2012). *Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies* [Case study on a project of the Wisconsin Initiative on Climate Change Impacts]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

⁸⁵ Kershner, J. M. (2012). *The Michigan Climate Coalition: Enhancing Networking and Collaboration, Communication and Action Around Climate Change in Michigan* [Case study on the Michigan Climate Coalition]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

⁸⁶ Gregg, R. M. (2012). *Climate Change Adaptation Planning at the State Level in Pennsylvania* [Case study on a project of the Pennsylvania Departments of Environmental Protection and Conservation and Natural Resources]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

⁸⁷ Gregg, R. M. & Hitt, J. L. (2012). *A Roadmap for Action: The Chicago Climate Action Plan* [Case study on a project of the City of Chicago]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

⁸⁸ Center for Clean Air Policy. Urban Climate Adaptation. www.ccap.org/index.php?component=programs&id=6

change, its impact, and related socioeconomic and environmental vulnerabilities, in order to inform decision makers about probable climate trends and advise them on identifying, assessing, promoting, and implementing local and regional adaptation strategies.”⁸⁹

Increase organizational capacity

Adequate internal organizational capacity is needed in order for adaptation strategies to be planned and implemented appropriately. This strategy includes enhancing internal institutional knowledge by training staff and developing or obtaining resources so that climate change can be understood and institutionalized within an organization’s day-to-day practices.

Training staff

Governmental and non-governmental organizations in the Great Lakes region have invested in staff training. Some of these trainings have been facilitated by other groups; for example, the City of Ann Arbor, Michigan, sent a team to the Institute for Sustainable Communities’ Climate Leadership Academy for training to help identify relevant mitigation and adaptation tools and resources to support staff in understanding how climate change could affect the programs they manage.⁹⁰

Other trainings have been created by individual organizations to support internal efforts. New York Sea Grant held a Climate Change Literacy Workshop for Extension Educators in August 2010 with funding through the Sea Grant Coastal Climate Change Adaptation Initiative. Forty participants, including Cornell Cooperative Extension, New York and Lake Champlain Sea Grant Extension, and National Weather Service staff, attended the meeting where sessions focused on how extension educators can communicate climate science to different audiences.⁹¹ The Great Lakes Sea Grant Network provided a “train the trainer” workshop during its Annual Meeting in October 2012 to train its outreach/extension educators on climate change impacts and adaptation planning.⁹² The Chicago Wilderness Climate Change Task Force is creating climate clinics, which are aimed at building the internal capacity of member organizations to implement measures recommended in the *Climate Action Plan for Nature*.⁹³ Finally, Chippewa National Forest hosted a training workshop for all staff in March 2011 on climate change impacts and adaptation responses on forests and grasslands⁹⁴; this workshop was developed as an extension of the U.S. Forest Service Northern Institute of Applied Climate Science’s Training in Advanced Climate Change Topics (TACCT) series. TACCT is a one-week course for natural resource practitioners that “provides advanced instruction on climate change science, concepts, and strategies for managing ecosystems for an uncertain future.”⁹⁵

⁸⁹ Ouranos <http://www.ouranos.ca/en>

⁹⁰ Kershner, J. M. (2012). *Climate Adaptation in the City of Ann Arbor, Michigan* [Case study on a project of the City of Ann Arbor]. Product of EcoAdapt’s [State of Adaptation Program](#) (Last updated October 2012)

⁹¹ Dunn, K.L. (2010). *NYSG Hosts Climate Science Workshop for Educators*. New York Coastlines, Fall 2010.

<http://www.seagrant.sunysb.edu/articles/t/nysg-hosts-climate-science-workshop-for-educators-new-york-coastlines-fall-2010>

⁹² Personal communication with H. Stirratt, NOAA, September 2012 and <http://www.seagrant.umn.edu/duluth2012/program.pdf>

⁹³ Feifel, K. M. (2012). *The Chicago Wilderness Climate Action Plan for Nature* [Case study on a project of the Chicago Wilderness]. Product of EcoAdapt’s [State of Adaptation Program](#) (Last updated October 2012)

⁹⁴ Rickers, M. (2011). *Chippewa National Forest Hosts All-Employee Climate Change Workshop*. www.fs.fed.us/r9/ssrs/story?id=5833

⁹⁵ Northern Institute of Applied Climate Science www.nrs.fs.fed.us/niaacs/climate/TACCT/

In addition, the National Oceanic and Atmospheric Administration (NOAA) has created three training modules that cover projected climate impacts, adaptation planning options, and tools aimed at educating regional organizations looking to incorporate climate change into their work. The first module presents an overview of predicted climate change impacts in the Great Lakes region and is designed to assist local decision makers in understanding the potential range of variability in climate change predictions and how they are likely to impact local communities. The second module presents a planning process to help communities conceptualize the effects of regional climate change predictions so they can assess their vulnerabilities, and describes strategies for stormwater management, drought, infrastructure, ecosystems, and urban heat. The third module highlights tools that have been developed to assist local communities with assessing climate change vulnerability and adaptation planning. The modules can be tailored towards specific communities and may be administered by Sea Grant Extension Staff or downloaded for personal use.⁹⁶

Resource development and acquisition

NOAA funded a Great Lakes supplement to the report, *Adapting to Climate Change: A Planning Guide for State Coastal Managers*, which was created to help coastal managers develop and implement adaptation strategies and plans.⁹⁷ The supplemental report was produced to provide more specific information on impacts on and guidance for the Great Lakes region, including case studies of climate change activities underway.⁹⁸

Coordinate planning and management

The effects of climate change will be felt at multiple scales and across jurisdictions and boundaries. Cross-jurisdictional and sectoral coordination can enhance adaptation planning and implementation. This strategy includes both informal and formal mechanisms; for example, enhancing information sharing and communications on one side and establishing partnerships to share resources on the other.

Regional coordination efforts are strong in the Great Lakes. For example, the Great Lakes Restoration Initiative involves a great deal of coordination at the federal level. The members of the Initiative's Task Force include the CEQ, Department of Agriculture (Animal and Plant Health Inspection Service, Forest Service, Natural Resources Conservation Service), Department of Commerce (NOAA), Department of Defense (U.S. Army Corps of Engineers), Department of Health and Human Services (Agency for Toxic Substances and Disease Registry), Department of Homeland Security (U.S. Coast Guard), Department of Housing and Urban Development, Department of the Interior (Bureau of Indian Affairs, Fish and Wildlife Service, Geological Survey, National Park Service), Department of State, Department of Transportation (Federal Highway

⁹⁶ Feifel, K. M. & Hitt, J. L. (2012). *The National Oceanic and Atmospheric Administration's Great Lakes Climate Initiatives* [Case study on projects of the National Oceanic and Atmospheric Administration]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

⁹⁷ 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>

⁹⁸ Feifel & Hitt 2012: *The National Oceanic and Atmospheric Administration's Great Lakes Climate Initiatives*

Administration, Maritime Administration), and the EPA.⁹⁹ Working together, this collaborative Task Force prioritizes and administers grants for restoration projects in the region.

Two other federally-funded efforts are the Great Lakes Integrated Sciences and Assessments (GLISA) and the U.S. Forest Service's Climate Change Response Framework. GLISA is a collaboration of the University of Michigan, Michigan State University, Ohio State University, and Michigan Sea Grant. It is comprised of leading climatologists, social scientists, and outreach specialists working to bridge the gap between producers and users of scientific information. Specific goals of GLISA include: (1) developing an integrated network of stakeholders that will contribute to production of policy and usable science; (2) conducting scientific research to address gaps in current knowledge; (3) compiling, synthesizing, and comparing existing climate knowledge in the region and developing new approaches to enhance usability; and (4) developing best practices for the use of climate projections in impact analyses and decision making. The GLISA website provides numerous resources including climate change education materials, news and events, current research projects, decision support tools, and funding opportunities. The group focuses on adaptation to climate change and variability for regional sectors, such as agriculture, watershed management, urban management, and natural resource-based tourism in the watersheds of Lake Huron and Lake Erie.¹⁰⁰

The U.S. Forest Service has created the Climate Change Response Framework, a highly collaborative approach that helps land managers understand the potential effects of climate change on forest ecosystems and integrate climate change considerations into management. The Framework is being applied in three regions – Northwoods (northern areas of Minnesota, Wisconsin, and Michigan), Central Appalachians (eastern Ohio, the eastern panhandle of Maryland and West Virginia), and Central Hardwoods (southern areas of Missouri, Illinois, and Indiana). The Framework stretches across forestlands owned and managed by private individuals, forest industries, tribes, and state, local, and federal agencies. It includes vulnerability assessments for forest ecosystems and guidance on how the assessment results can be used to develop adaptation strategies within current decision-making and planning processes. As part of the Northwoods Framework, a collection of resources was compiled for northern Wisconsin forest managers to help them incorporate climate change considerations into management and devise adaptation strategies. The resources included a description of the overarching Framework, a menu of adaptation strategies and approaches directly relevant to forests in northern Wisconsin, a workbook process to help incorporate climate change considerations into forest management planning and develop adaptation strategies, and examples of how these resources can be used in real-world situations.¹⁰¹

Tribes and states are also working to coordinate regional efforts. The Manajiwini Project, funded by the Upper Midwest and Great Lakes Landscape Conservation Cooperative, is a collaboration

⁹⁹ Gregg, R. M. (2012). *Great Lakes Restoration Initiative* [Case study on a project of the Great Lakes Restoration Initiative]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁰⁰ Great Lakes Integrated Sciences and Assessments <http://www.glista.umich.edu/>

¹⁰¹ Kershner, J. M. (2012). *The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region* [Case study on a project of the Northern Institute of Applied Climate Science]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

between university scientists (University of Michigan, Lakehead University, Michigan State University, University of Toronto), tribes (Sault Ste. Marie Tribe of Chippewa Indians, Anishinabek Nation), The Nature Conservancy, and the Great Lakes Indian Fish and Wildlife Commission. The project is aimed at improving tribal and First Nation engagement in cooperative natural resource conservation efforts under changing climate conditions. Tribal and First Nation representatives are collaborating with scientists and managers to develop principles respective of tribal values and traditional ecological knowledge that can be incorporated into regional resource conservation frameworks, and assess climate and land use planning initiatives and projects being implemented by tribes and First Nations in the Great Lakes.¹⁰² At the state level, the Michigan and Wisconsin Departments of Natural Resources have signed a Memorandum of Understanding to collaborate on climate change adaptation and science.¹⁰³

Conduct research, studies, and assessments

Collecting information on and understanding climate change are critical steps in taking adaptation action. This includes understanding what changes are occurring and the implications of those changes; these activities include impacts assessments, vulnerability assessments, and targeted research studies.

Conduct/gather additional research and data (impacts assessments)

This strategy includes research studies, modeling, and assessments; these activities may happen at the scientific level but traditional ecological knowledge and citizen science efforts are also critical pieces that support knowledge enhancement.

The U.S. Global Change Research Program (USGCRP) has supported a series of assessments¹⁰⁴; for example, a chapter in the 2009 report *Global Climate Change Impacts in the United States* is a dedicated impacts assessment of the Midwest region.¹⁰⁵ In addition, the USGCRP is coordinating the 2013 National Climate Assessment with multiple partners. Due for release in 2013, the report includes chapters on sectors, habitats, and geographies relevant to the Great Lakes region.¹⁰⁶

The WICCI released a full assessment of both climate change impacts and adaptation strategies in 2011.¹⁰⁷ This is a unique report as it was not produced through a government mandate but rather through a bottom-up process led by the University of Wisconsin-Madison and the Wisconsin

¹⁰² Manajiw Project <http://www.greatlakeslcc.org/about-lcc-projects/2011-projects/fy11-02/>

¹⁰³ Memorandum of Understanding Between the Michigan Department of Natural Resources and the Wisconsin Department of Natural Resources to Establish and Implement a Partnership for Climate Change Adaptation http://www.michigan.gov/documents/deq/dnre-climatechange-MI-WI_MOU_Climate_Change_332449_7.pdf

¹⁰⁴ Gregg, R. M. (2010). *U.S. Global Change Research Program* [Case study on a project of the U.S. Global Change Research Program]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/2761> (Last updated October 2012)

¹⁰⁵ *Global Climate Change Impacts in the United States*. (2009). Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts>

¹⁰⁶ National Climate Assessment <http://www.globalchange.gov/what-we-do/assessment>

¹⁰⁷ Wisconsin's Changing Climate: Impacts and Adaptation. (2011). Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin. http://www.wicci.wisc.edu/report/2011_WICCI-Report.pdf

Department of Natural Resources. Individual assessments were provided by the 15 working groups set up by the WICCI to inform this report; these assessments are topic-based (Climate, Adaptation), place-based (Green Bay, Milwaukee), and sector-based (Agriculture, Central Sands Hydrology, Coastal Communities, Coldwater Fish and Fisheries, Forestry, Human Health, Plants and Natural Communities, Soil Conservation, Stormwater, Water Resources, Wildlife). These individual reports are available on the WICCI website.¹⁰⁸

Species-level impacts assessments are occurring at a few different scales. In Minnesota, the National Park Service, the University of Minnesota's Natural Resources Research Institute, and the U.S. Geological Survey are collaborating on a project to track moose movement within Voyageurs National Park using GPS collars that provide location and temperature data at different time intervals. The data collected will allow researchers to test hypotheses about moose movement in relation to changes in temperature and weather and help identify areas that may act as potential climate refugia.¹⁰⁹ Also, scientists at Michigan State University are investigating the impact of changing climate conditions on population growth and survival of Great Lakes lake whitefish. They plan to create a model linking climate factors with lake whitefish population dynamics in order to provide a decision support tool and associated guidance for lake whitefish harvest management. The tool will help decision makers coordinate lake whitefish conservation efforts and harvest strategies under varying climate regimes.¹¹⁰

Conduct vulnerability assessments and studies

Vulnerability assessments and studies help practitioners evaluate and understand the implications of climatic changes by examining exposure, sensitivity, and adaptive capacity. These assessments can identify impacts, what is at risk, and the range of options available to increase resilience and decrease vulnerability. Vulnerability assessments are gaining traction at multiple scales and for multiple purposes; for example, Executive Order 13514 mandates the evaluation and assessment of vulnerabilities that climate change may pose to federal agency operations and missions.¹¹¹ Most examples from the Great Lakes region are assessments of habitats and species.

Habitat assessments

The National Park Service's Geologic Resources Division, in partnership with the U.S. Geological Survey, has conducted assessments of 23 park sites. As part of this project, assessments of Apostle Islands National Lakeshore (Wisconsin), Indiana Dunes National Lakeshore (Indiana), and Sleeping Bear Dunes National Lakeshore (Michigan) have been conducted with respect to lake level changes. The project involves creating maps of vulnerable areas using the Coastal Change Potential Index,

¹⁰⁸ Gregg 2012: *Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies*

¹⁰⁹ Hitt, J. L. (2010). *Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA) Using GPS Telemetry* [Case study on a project of Voyageurs National Park]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹¹⁰ Lynch, A. & Taylor, W.W. (2012). *Developing a Decision Support Tool for Great Lakes Lake Whitefish Harvest Management in a Changing Climate*. Ed. Kirsten Feifel [Case study on a project of Michigan State University's Center for Systems Integration and Sustainability]. Retrieved from CAKE: www.cakex.org/case-studies/5240 (Last updated October 2012)

¹¹¹ Executive Order 13514. (2009). Federal Leadership in Environmental, Energy, and Economic Performance. <http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/pdf/E9-24518.pdf>

which allows scientists to quantify potential physical changes to the shoreline from future lake level changes.¹¹²

A regional climate change vulnerability assessment was conducted on wetlands in Lake Ontario, Lake Erie, and Lake St. Clair by Environment Canada, Fisheries and Oceans Canada, and the University of Waterloo. Using a literature review, surveys, aerial photography analysis, modeling, and stakeholder outreach and engagement, the project team examined wetland communities' responses to lake level changes (historical and anticipated) and adaptation responses (e.g., land use policy changes, lake regulation, dyking). The three major components of the assessment were wetland modeling, adaptation strategies assessment, and stakeholder engagement.¹¹³

Species assessments

Species-level vulnerability assessments have been conducted in Illinois, Michigan, Minnesota, and Wisconsin. In Illinois, The Nature Conservancy partnered with the Illinois Department of Natural Resources on a vulnerability assessment of 163 species from the state's list of "Species in Greatest Need of Conservation" in its State Wildlife Action Plan (SWAP).¹¹⁴ Using NatureServe's Climate Change Vulnerability Index tool, project staff ranked and assessed the relative vulnerability (from Extremely Vulnerable to Population Increase Likely) of plant and animal species to climate change. The project team created a climate change update¹¹⁵ for the SWAP based on the results from the vulnerability assessment. For each of the "campaigns" listed in the SWAP (e.g., Streams, Farmland and Prairies, Forests, Wetlands, Invasive Species, Land and Water Stewardship, and Green Cities), conservation actions from the 2005 plan were analyzed and recommendations provided for consideration of climate change effects. For example, the 2005 plan calls for the protection and restoration of near-stream and in-stream habitats and processes; the update recommends planting and enhancing riparian vegetation that can provide shade and microclimate refugia to limit thermal stress on species.

The Michigan Department of Natural Resources is examining the vulnerability of Kirtland's warbler to climate change and developing ways to address this vulnerability. Kirtland's warblers are currently endangered and rely on Jack pine forests, which will likely be replaced by aspen and oaks along the southern margin of their range due to warming temperatures.¹¹⁶

¹¹² Gregg, R. M. (2010). *Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise and Lake Level Changes* [Case study on a project of the National Park Service - Geologic Resources Division and the U.S. Geological Survey - Woods Hole]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/2815> (Last updated October 2012)

¹¹³ Feifel, K. M. (2012). *Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Adaptation Strategies* [Case study on a project of Environment Canada]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹¹⁴ Kahl, K., Hall, K., Walk, J., Hagen, S., Lange, A., & Doran, P. (2011). *Updating the Illinois Wildlife Action Plan: Using a Climate Change Vulnerability Assessment to Inform Conservation Priorities*. Ed. Rachel M. Gregg. [Case study on a project of The Nature Conservancy – Great Lakes Project]. Retrieved from CAKE: <http://www.cakex.org/case-studies/5241> (Last updated March 2012)

¹¹⁵ Walk, J., S. Hagen, & A. Lange. (2011). *Adapting Conservation to a Changing Climate: An Update to the Illinois Wildlife Action Plan*. Report to the Illinois Department of Natural Resources. Illinois Chapter of the Nature Conservancy, Peoria, IL. <http://conserveonline.org/library/adapting-conservation-to-a-changing-climate-an/view.html>

¹¹⁶ Koslow, M. (2010). *Improving the Odds: Using Climate-readiness Planning to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem*. National Wildlife Federation. <http://www.nwf.org/~media/PDFs/Global-Warming/Reports/Great-Lakes-Adaptation.ashx>

As part of the Northwoods Climate Change Response Framework (which includes portions of Minnesota, Michigan, and Wisconsin), project staff assessed the vulnerabilities of individual tree species and forest or natural community types. Gridded historical and modeled climate change information, as well as two different modeling approaches (climate envelope and process), were used to model impacts on tree species. A group of experts were also convened to evaluate individual species' sensitivity and ground-truth model results. The vulnerability assessment results were used to create maps of the ecoregion showing where species might decline in the future.¹¹⁷

Initiate targeted research program(s) and studies

Investing in and enhancing targeted research programs and studies is important in order to understand the effects of climate change on natural resources. These initiatives can aid adaptation efforts by establishing a baseline from which to measure change or by addressing the specific uncertainties and variables that may be hindering progress on adaptation action.

Canada's Regional Adaptation Collaboratives (RAC) Climate Change Program was created to coordinate research, planning, and action related to climate change adaptation.¹¹⁸ Two RACs are located in the Great Lakes region – Quebec and Ontario. The Quebec RAC has focused its climate change adaptation efforts on three themes: built environment, water management, and socioeconomic activities, such as forestry, agriculture, tourism, and recreation. The effort has been led by Ouranos with over 20 partners in the federal, private, and non-governmental worlds.¹¹⁹ The Ontario RAC has focused its efforts on three themes: extreme weather risk management, water management, and community development planning. The effort has been led by the Ontario Ministry of the Environment with partners in the Ontario Ministry of Natural Resources, Ontario Ministry of Municipal Affairs and Housing, Clean Air Partnership, Ontario Centre for Climate Impacts and Adaptation Resources, Toronto and Region Conservation Authority, Association of Canadian Educational Resources, Institute for Catastrophic Loss Reduction, York University, and Toronto Public Health.¹²⁰ The entire RAC Program is ending in December 2012; Natural Resources Canada is planning to build on the efforts of the RACs through a new initiative called the Adaptation Platform (2011-16).

Other examples are related to species studies. Scientists at Michigan State University are examining bird abundance and distribution and their relationship with changes in land cover and climate in the Great Lakes region. This information will be used to develop models that can provide spatially explicit forecasts of future avian responses, which will be incorporated into bird conservation

¹¹⁷ Kershner 2012: *The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region*

¹¹⁸ Feifel, K. M. (2012). *Canada's Regional Adaptation Collaboratives Climate Change Program* [Case study on a project of Natural Resources Canada]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹¹⁹ Feifel, K. M. (2012). *Quebec Regional Adaptation Collaborative* [Case study on a project of Natural Resources Canada and Ouranos]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹²⁰ Feifel, K. M. (2012). *Ontario Regional Adaptation Collaborative* [Case study on a project of Natural Resources Canada and the Ontario Ministry of Environment]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

decision making.¹²¹ In addition, scientists at the U.S. Geological Survey Great Lakes Science Center are updating a regional climate model to predict changes in water level, water temperatures, and ice cover for the Great Lakes basin in the next 50-100 years. These models will be used along with long-term data sets and time series models to explore how climate influences variability in fish populations in lakes Michigan and Huron. This effort will be used to forecast future fish production and will be presented to resource managers throughout the region to aid in species management.¹²²

Conduct training and planning exercises

Workshops, stakeholder engagement processes, and scenario planning exercises can not only provide much needed information but also motivate action and implementation of on-the-ground projects. Conservation and management practitioners need assistance in conceptualizing the range of issues climate change poses, developing or locating needed information to make decisions, and finding other practitioners with whom to interact and engage as adaptation approaches are created.

Create/host adaptation workshops

Training and planning workshops can provide context and guidance about climate change. These workshops may present climate change information, introduce adaptation theory and practice, and help participants develop their own strategies. Climate change adaptation workshops have been conducted in the region over the last two decades. For example, the Great Lakes-St. Lawrence Basin Project, a five-year (1992-1997) binational planning effort between the United States and Canada and coordinated by Environment Canada, Atmospheric Environment Service, Environmental Adaptation Research Group, and the NOAA Great Lakes Environmental Research Laboratory, included a symposium *Adapting to Climate Change and Variability in the Great Lakes-St. Lawrence Basin*. The May 1997 meeting was one of the earliest in the region to be focused on climate change risk, vulnerability, and adaptation responses. About 150 participants met to discuss the range of projected impacts and associated risks, information needs, potential adaptation strategies, priorities for action, and potential barriers.¹²³ Since then, many other regional workshops have been held. In 2008, the Environmental Science and Policy Program of Michigan State University hosted a conference titled *Climate Change in the Great Lakes Region*. More than 160 individuals from academia, business, non-governmental organizations, and government attended the conference; key discussions included the effects of climate change in the region, uncertainty and climate-related decisions, research needs, and prescriptions for action.¹²⁴ In 2011, NOAA hosted a series of capacity building adaptation workshops based on the trainings developed by the Padilla Bay National Estuarine Research Reserve

¹²¹ Distribution and Abundance of Breeding Birds in the Upper Midwest and Great Lakes Region as Influenced by Climate and Land Cover Change <http://www.greatlakeslcc.org/what-we-do/research/>

¹²² Forecasting Climate Change Induced Effects on Recreational and Commercial Fish Populations in the Great Lakes https://nccwsc.usgs.gov/sites/default/files/documents/project/summaries/Summary_for_NCCWSC-Bunnell.pdf

¹²³ Environmental Adaptation Research Group. (1998). *Adapting to Climate Change and Variability in the Great Lakes-St. Lawrence Basin: Proceedings of a Binational Symposium*.

http://www.env.uwaterloo.ca/research/aird/aird_pub/Adapting_to_Climate_Change_in_the_GLSLB.pdf

¹²⁴ Michigan State University. (2008). *Climate Change in the Great Lakes Region: Decision Making Under Uncertainty*. Key Messages from the “Climate Change in the Great Lakes Region” Conference (April 2008) and the International Symposium “Climate Change in the Great Lakes Region: Decision Making Under Uncertainty” (March 2007). http://www.espp.msu.edu/climatechange/2008/CC-key_messages.pdf

(NERR) and Washington Sea Grant.¹²⁵ The Old Woman Creek NERR and the Lake Superior NERR worked with other partners to customize the workshop agenda and materials to address Great Lakes issues (e.g., land use, stormwater, disaster preparedness, natural resource management). Workshops were targeted toward state and local decision makers and planners and held in Cleveland (Ohio), Duluth (Minnesota), and Green Bay (Wisconsin).¹²⁶ Finally, the Menominee Nation Tribal Summit was hosted by the College of Menominee Nation Sustainable Development Institute in August 2011 in order to exchange information on research projects related to climate change and resilience and to begin a discussion on the research needs of Great Lakes tribes.¹²⁷

State-level workshops have also been held in the last few years. A conference titled *Ohio's Wildlife in a Changing Climate: Sustaining Habitats and Diversity* was held for wildlife managers, fish and wildlife biologists, naturalists, and other conservation professionals. The conference included presentations on regional climate trends, likely impacts on habitat and wildlife, planning and decision making in the face of uncertainty, and regional examples of climate adaptation. It was intended to provide foundational information to help conservation and natural resource professionals address climate change impacts on habitat and wildlife in their plans and management strategies.¹²⁸ In Michigan, a workshop was convened to support the integration of climate change into the State Wildlife Action Plan (SWAP). The Michigan Department of Natural Resources, National Wildlife Federation, and Michigan United Conservation Clubs led the workshop, which allowed participants to assess issues including management responses, shaping federal and state policy, and implementation of the current SWAP. Important research needs were also identified, including vulnerability assessments, connectivity planning, information and education, and the development of multiple climate-ready plans to deal with uncertainty.¹²⁹

At the local level, a variety of workshops have been held to enhance capacity. Pennsylvania Sea Grant held a workshop in Erie County in September 2010. Funded through the Sea Grant Coastal Climate Change Adaptation Initiative, the workshop was held to increase community understanding of climate change impacts, develop partnerships to increase resilience, train participants on adaptation, and identify where adaptation could be incorporated into existing activities.¹³⁰

Finally, Freshwater Future developed the Great Lakes Community Climate Program to help local residents and community groups incorporate climate change into decision-making activities, such as advocacy, engagement, protection, and restoration of lakes, wetlands, rivers, and shorelines in the region. Since 2010, Freshwater Future and EcoAdapt have hosted climate symposia in Detroit, Milwaukee, Toronto, Buffalo, and Duluth, during which community groups are trained in climate

¹²⁵ Gregg, R.M. (2010). *The National Estuarine Research Reserve's "Planning for Climate Change" Workshop* [Case study on a project of the Padilla Bay National Estuarine Research Reserve and Washington Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/849> (Last updated March 2010)

¹²⁶ Feifel & Hitt 2012: *The National Oceanic and Atmospheric Administration's Great Lakes Climate Initiatives*

¹²⁷ Personal communication with M. Emery, U.S. Forest Service Northern Research Station, April 3, 2012.

¹²⁸ Ohio Department of Natural Resources <http://www.dnr.state.oh.us/Default.aspx?tabid=23624>

¹²⁹ Koslow 2010

¹³⁰ Gregg, R. M. (2012). *Pennsylvania Sea Grant's Climate Change Outreach and Research Projects* [Case study on a project of Pennsylvania Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

change adaptation. Each workshop orients participants to climate change science basics and predicted regional impacts before focusing on brainstorming and developing adaptation solutions. The goal of each workshop is to ensure that participants leave having learned how to approach their work from a climate-informed perspective.¹³¹

Create stakeholder engagement processes

Engaging stakeholders and gaining buy-in is a critical piece to the climate adaptation process. This strategy includes multiple levels of engagement, ranging from soliciting input in public venues (e.g., meetings, workshops) to more personalized interactions (e.g., one-on-one). This engagement may also be active (e.g., role playing exercises) or passive (e.g., interactive websites, public comment).

Active engagement

Stakeholders are sometimes engaged to solicit information that can help direct climate change research and adaptation planning. For example, researchers at Michigan State University (MSU) worked with MSU Extension educators and the Michigan Farm Bureau to organize a series of focus group discussions with Michigan farmers, representatives from the agriculture industry, MSU researchers, legislative aids, and environmentalists. The first round of focus groups included discussions of participants' existing perspectives about climate change, where people were getting their information about climate change, how they see climate change and agriculture being linked, and what topics would be important to understand. The second round of focus groups covered three themes: (1) perceptions of climate change and if it has or would lead to adaptation; (2) perceptions of climate change adaptation and adaptation in general; and (3) what would participants need in order to adapt. The researchers have created trainings, fact sheets, and compiled summaries of conversations with farmers so that MSU Extension educators and agricultural professionals can begin incorporating this information in their programming to reach agricultural producers across Michigan.¹³²

Engagement may also be used to refine decisions or products. For example, the Great Lakes lake whitefish decision support tool will be refined and revised through collaborations with Great Lakes Sea Grant Extension Educators, tribal representatives, and commercial fish producers in order to facilitate buy-in and use.¹³³

Passive engagement

Websites provide an easy forum through which stakeholder engagement may occur. Some websites are targeted to specific user groups; for example, Wisconsin Sea Grant created the Coastal Climate Wiki, which may be modified by registered Sea Grant and NOAA staff involved in any climate

¹³¹ Hitt, J. L. & Gregg, R. M. (2012). *Fostering a Climate-Informed Community Perspective in the Great Lakes: The Great Lakes Community Climate Program* [Case study on a project of Freshwater Future]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹³² Kershner, J. M. (2012). *Helping Michigan's Farmers Understand and Adapt to the Impacts of Climate Change* [Case study on a project of Michigan State University Extension and Kellogg Biological Station – Michigan]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹³³ Lynch & Taylor 2012

research, education, or outreach.¹³⁴ Others are designed to provide information and solicit feedback from users. The National Fish, Wildlife, and Plants Climate Adaptation Strategy website solicited review and public comment on the initial draft in early 2012. Another version of the strategy, drafted by federal, tribal, and state natural resource representatives to guide adaptation action over the next 50–100 years, is in progress.¹³⁵

Conduct scenario planning exercises

Scenario planning is being employed more frequently in the development of adaptation responses. This strategy allows users to identify scenarios and responses and evaluate potential policy and management options. Scenario planning guides participants through the identification of adaptation responses that operate well across multiple scenarios; it helps users identify options for overcoming uncertainty and can also improve adaptive management practices.¹³⁶ The National Park Service has used scenario planning to examine potential climate change impacts and adaptation responses for individual parks; these planning workshops were piloted at Joshua Tree National Park¹³⁷ and Kaloko-Honokōhau National Historical Park¹³⁸ in 2007. This series was then expanded to four additional regions in 2010–2011, which included an October 2010 workshop for the Great Lakes and Atlantic Coast bioregions.¹³⁹

Increase/improve public awareness, education, and outreach efforts

This strategy includes increasing and improving the links between climate science, management, conservation, and public awareness. Informal and formal education mechanisms (e.g., presentations, websites, fact sheets and brochures, school curriculums) can be used to support this strategy. Enabling managers and decision makers to incorporate climate adaptation into practice requires that the appropriate information be available in useable forms when needed. The broader public also needs to be engaged and made aware of the potential ways that climate change may affect the economy, natural resources, livelihoods, health, and well-being. Gaining public buy-in may also increase political and social capital to support climate adaptation action at local, regional, national, and international levels.

¹³⁴ Gregg, R. M. (2012). *Enhancing Climate Change Education and Outreach for Wisconsin's Coastal Communities* [Case study on a project of Wisconsin Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹³⁵ Gregg, R. M. (2010). *Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States* [Case study on a project of the U.S. Fish and Wildlife Service]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹³⁶ Peterson, G., G.S. Cummings, & S.R. Carpenter. (2003). Scenario Planning: A Tool for Conservation in an Uncertain World. *Conservation Biology* 17(2): 358–366.

¹³⁷ Kershner, J. (2011). *Scenario Planning in Joshua Tree National Park* [Case study on a project of Joshua Tree National Park]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/2904> (Last updated January 2011)

¹³⁸ Feifel, K. (2010). *Scenario Planning Pilot Study for Kaloko-Honokōhau National Historical Park* [Case study on a project of the National Park Service]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/1583> (Last updated July 2010)

¹³⁹ Weeks, D., P. Malone, & L. Welling. (2011). *Climate Change Scenario Planning: A Tool for Managing Parks into Uncertain Futures*. *ParkScience* 28(1):26–33. <http://www.nature.nps.gov/ParkScience/index.cfm?ArticleID=475>

Presentations

Ottawa National Forest held a climate change outreach event for staff and area high school and college students. The event included presentations from local experts on climate change and its current and expected impacts on northern Michigan forests, presentations on sustainable operations of buildings, and a facilitated group discussion between personnel and experts about managing the Ottawa National Forest under changing climate conditions.¹⁴⁰

Websites

Climate Wisconsin is a website dedicated to telling local stories of climate change impacts around the state through multimedia formats. The stories provided (on Farming, Forestry, Extreme Heat, Shipping, Ice Fishing, Birkebeiner ski race, Sugaring, Phenology, Fly Fishing, and Adaptation and Mitigation) are supported and informed by research conducted by the WICCI. The site also hosts two interactive sections for users to view changes in temperature and ice cover. Both the stories and interactive pieces contain descriptive text and directives for teachers on how to apply the information provided in the classroom.¹⁴¹

The *Climate Change in the Great Lakes Region: Starting a Public Discussion* website hosts recordings, PowerPoint presentations, and summaries of eight seminars held in Wisconsin between March and September 2007 on climate change.¹⁴² The initiative was supported by Wisconsin Sea Grant, the Wisconsin Coastal Management Program, and NOAA. In order to extend the utility of the series and continue the discussion, all of the seminars are provided for free on the website; in addition, a summary report and DVD of the series are available in the Wisconsin Sea Grant store.¹⁴³ The Lake Superior Binational Forum also has a dedicated page on its website to raising climate change awareness that includes a three-part video series created by scientists at the Large Lakes Observatory on climate change and Lake Superior.¹⁴⁴

Fact sheets

Researchers at Michigan State University have developed a series of fact sheets (available in English and Spanish) on climate change and agriculture, which explain the basics of greenhouse gas emissions, how they are related to agriculture, how climate change will affect Michigan field crop agriculture, and what the industry can do about it. They also host trainings for communicating climate change in order to inspire people to adapt; organize in-service trainings for educators on water, climate change, and agriculture; and host workshops linking climate scientists to journalists.¹⁴⁵

Reports

The Yellow Dog Watershed Preserve, a watershed protection group based in Big Bay, Michigan, commissioned a report examining how regional climate change is likely to affect the mining industry,

¹⁴⁰ U.S. Forest Service <http://www.fs.fed.us/climatechange/advisor/scorecard/education.html>

¹⁴¹ Climate Wisconsin, <http://climatemwisc.org>

¹⁴² Gregg 2012: *Enhancing Climate Change Education and Outreach for Wisconsin's Coastal Communities*

¹⁴³ UW Aquatic Sciences Center <http://aqua.wisc.edu/publications/ProductDetails.aspx?productID=552>

¹⁴⁴ Lake Superior Binational Forum <http://www.superiorforum.org>

¹⁴⁵ Kershner 2012: *Helping Michigan's Farmers Understand and Adapt to the Impacts of Climate Change*

the environment, and humans in the Great Lakes region. Specifically, the report discusses problems that the Kennecott Eagle Mine, an underground nickel and copper mine, might face as a result of projected regional climate change impacts and recommends actions for protecting the environment and human health. The report was disseminated to local municipalities and federal and state representatives with the hope of influencing them to require Kennecott to revise its environmental protection plan to include climate change.¹⁴⁶

The Huron River Watershed Council (HRWC) released a report that sought to educate Huron River communities and the public about the impacts of climate change on the region's freshwater resources. The report included a discussion of the effects of climate change on Michigan, sections of the watershed, and fish populations, and described solutions to help increase the resilience of the watershed to climate impacts. This report has served as the impetus for the HRWC to create targeted climate change projects, such as Climate-Resilient Communities and Saving Water Saves Energy.¹⁴⁷

Formal education and curricula

Ohio Sea Grant is updating existing lesson plans for middle and high schools to include climate change and its likely effects in the Great Lakes region. Specifically, they plan to update references to coupled climate-ocean models with regional projected changes; regional examples of specific changes already being documented; and science background references for further information. Products will be disseminated online and through national and state public presentations and meetings. Educators and teachers will also have opportunities to participate in short courses on regional climate change and impacts to coastal communities and ecosystems in order to increase awareness of regional climate issues.¹⁴⁸

Create/enhance resources and tools

Resources and tools can make adaptation decision making and action easier; many of these have been developed for the Great Lakes. These resources and tools include those that deal with guidance and decision support, data acquisition and management, modeling and analysis, and information exchange. These tools can help managers and other practitioners identify priority habitats and species, assess risk and vulnerability in different sectors, generate other resources to support implementation, and engage with other like-minded practitioners.

Guidance and decision support

The National Wildlife Federation and EcoAdapt received funding to develop climate-smart restoration guidance materials for the Great Lakes region. The partners developed a technical

¹⁴⁶ Feifel, K. M. & Whittaker, E. (2012). *Climate Change, the Great Lakes, and Mining* [Case study on a project of the Yellow Dog Watershed Preserve]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁴⁷ Gregg, R. M. (2012). *Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed* [Case study on a project of the Huron River Watershed Council]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁴⁸ Ohio Sea Grant <http://www.ohioseagrant.osu.edu/research/globalchange/?ID=E/E-002-PD>

guidance document, *Restoring the Great Lakes' Coastal Future*,¹⁴⁹ to aid NOAA and its partners and grantees in planning and implementing climate-smart restoration projects on the ground. The guidance document serves as a climate-smart framework for restoration, providing users with a suite of tools and a methodology to approach restoration given the reality of climate change. The methodology includes six steps:

1. Identify restoration-specific goals and targets
2. Identify possible approaches to restoration projects
3. Conduct a vulnerability assessment of both goals and targets and project approaches
4. Develop climate-smart management options
5. Prioritize and implement specific management options
6. Monitor, evaluate, and revise restoration approaches

The guide provides case studies of how regional projects could incorporate a climate-smart restoration framework into their work. These examples, including the restoration of whitefish spawning habitat and sea lamprey control, are presented in tabular format for easy reference. Tables review vulnerability of project goals, targets, and approaches to climate change and present options for reducing that vulnerability on a number of levels. More detailed information on conducting a vulnerability assessment and additional resources on restoration, climate change adaptation, and the Great Lakes region are provided in appendices.¹⁵⁰

Data acquisition and management

Examples of existing data resources and tools relevant to the Great Lakes region include Climate Wizard, Data Basin, NOAA's Digital Coast, and the Great Lakes Observing System. Climate Wizard is a web-based mapping tool developed by The Nature Conservancy that allows users to view both historic and projected temperature and precipitation maps.¹⁵¹ Data Basin's Climate Center provides a forum through which users can share and use spatial data and analyses; an entire gallery (e.g., collection of datasets and maps) is devoted to the Great Lakes region.¹⁵² The Topographic and Bathymetric Data Inventory, a component of NOAA's Digital Coast,¹⁵³ was created to collect regionally-specific elevation data sets; the Great Lakes inventory was completed in May 2010 through a Great Lakes Restoration Initiative grant.¹⁵⁴ The Great Lakes Observing System (GLOS)¹⁵⁵ was established to support a more comprehensive and coordinated approach to data and information access. Its purpose is to connect data users with data providers in order to support decision making. The four primary focus areas of the GLOS are Ecosystem Health, Public Health and Water Security, Maritime Operations, and Climate Change and Natural Hazards. In the latter

¹⁴⁹ Glick, P., J. Hoffman, M. Koslow, A. Kane, & D. Inkley. (2011). *Restoring the Great Lakes' Coastal Future: Technical Guidance for the Design and Implementation of Climate-Smart Restoration Projects*. National Wildlife Federation, Ann Arbor, MI.

http://www.nwf.org/~media/PDFs/Global-Warming/Climate-Smart-Conservation/NWF_Restoring_the_Great_Lakes_Coastal_Future_090211.ashx

¹⁵⁰ Gregg, R. M. & Hitt, J. L. (2012). *The National Wildlife Federation's Climate-Smart Restoration Partnership in the Great Lakes* [Case study on a project of the National Wildlife Federation and EcoAdapt]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁵¹ Climate Wizard <http://www.climatewizard.org>

¹⁵² Data Basin. Great Lakes Data. <http://bit.ly/M937Sw>

¹⁵³ NOAA's Digital Coast <http://www.csc.noaa.gov/digitalcoast/>

¹⁵⁴ NOAA's Topographic and Bathymetric Data Inventory <http://www.csc.noaa.gov/topobathy/#>

¹⁵⁵ Great Lakes Observing System (GLOS) <http://www.glos.us>

focal area, GLOS is prioritizing the development of adaptation strategies by providing monitoring and modeling support to Great Lakes decision makers for flooding, non-point source pollution, stormwater management, shoreline management, and water availability issues.¹⁵⁶

Another Great Lakes-specific data source is in development. The Nature Conservancy and U.S. Geological Survey are working with a broad network of scientists, natural resource professionals, agency staff, and non-governmental organizations to design and develop a shared Great Lakes information management and delivery system (IMDS) to support the Upper Midwest/Great Lakes Landscape Conservation Cooperative. In addition, the partners will initiate one or more demonstration projects to provide proof of concept, and promote and support the long-term development and maintenance of the Great Lakes IMDS to support strategic habitat conservation.¹⁵⁷

Modeling and analysis

Modeling and analysis tools have been created to support adaptation decision making in built and natural environments. For water resources planning, the Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT) and the Climate Resilience Evaluation and Assessment Tool (CREAT) are available. N-SPECT, available through NOAA's Digital Coast, allows users to visualize existing patterns of runoff volumes and pollution and to analyze possible future scenarios related to land use changes.¹⁵⁸ The EPA developed CREAT to assist utilities in understanding and assessing risks from climate change impacts and evaluating adaptation options.¹⁵⁹

Two resources specific to the Great Lakes region are in use or in development. The GLOS Model Inventory was designed to allow users to share and find tools, people, and organizations engaged in ecosystem health, public health, marine operations, and climate change adaptation.¹⁶⁰ In addition, scientists in Quebec are designing tools to assist in the economic and spatial analysis of ecological goods and services that can help mitigate climate change impacts on hydrological functions of wetlands. The pilot sites are the Yamaska and Bécancour rivers in the St. Lawrence River lowlands.¹⁶¹

Information exchange

The following websites are examples of forums for information exchange in the region:

¹⁵⁶ GLOS <http://glos.us/sites/default/files/documents/Blueprint%20for%20GI%20Decision%20Making.pdf>

¹⁵⁷ Designing a Shared Great Lakes Information Management & Delivery System to Support Strategic Habitat Conservation <http://www.greatlakeslcc.org/wp-content/uploads/2011/03/Great-Lakes-Info-System-Project-Summary.pdf>

¹⁵⁸ Nonpoint-Source Pollution and Erosion Comparison Tool <http://www.csc.noaa.gov/digitalcoast/tools/nspect/>

¹⁵⁹ Gregg, R.M. (2010). *Climate Ready Water Utilities Program* [Case study on a project of the U.S. Environmental Protection Agency's Office of Water]. Product of EcoAdapt's *State of Adaptation Program*. Retrieved from CAKE: <http://www.cakex.org/case-studies/2758> (Last updated December 2010)

¹⁶⁰ GLOS Model Inventory <http://glos.us/data-tools/great-lakes-model-inventory>

¹⁶¹ Tools for the Hydrological, Economic, and Spatial Analysis of Ecological Services Provided by Wetlands of the Lower St. Lawrence Lowlands: Adaptation to Climate Change http://www.ouranos.ca/media/publication/222_Fournier_2012_web_Eng.pdf

- GLISAclimate is aimed at connecting the producers and users of climate science information. Registered users can contribute data through the site's Resource Portal and are encouraged to collaborate with other users to develop ideas and solutions to climate change.¹⁶²
- The Adaptation Collaboratory was developed with funding from the National Science Foundation and the University of Notre Dame. The site aims to facilitate collaboration between practitioners, serve as a clearinghouse of adaptation information, and allow users to run visualization simulations and scenarios.¹⁶³
- *Mainstream: The National Water Adaptation to Climate Change Project* was created to collect and present information on climate change and water resources management. One component of the project was to create a compendium of tools to support water resources practitioners from municipalities, watershed organizations, private sector groups, advocacy groups, and provincial/territorial agencies to integrate climate change adaptation into management.¹⁶⁴
- The Climate Adaptation Knowledge Exchange (CAKE) is an online resource designed to help managers see the wealth of information that exists on adaptation and to support open access information exchange between practitioners from around the world. CAKE was created to simplify the tasks of discovery, comparison, and application that overwhelm so many individuals looking to address climate change in their work. The site consists of case studies of on-the-ground adaptation efforts, a virtual library of useful resources to support adaptation action, a community forum with an expert advice column, a directory of individuals and organizations rich with adaptation knowledge, and a tools section full of online resources to support implementation.¹⁶⁵

Monitor climate change impacts and adaptation efficacy

Monitoring can help practitioners track environmental changes and identify needed modifications in applied management strategies. It may be used to demonstrate correlations between climatic and environmental changes, assess climate change impacts on habitats and species, provide early warning signals that may indicate a need for management interventions, and evaluate the efficacy of adaptation action. A lot of effort has been invested in the region in monitoring environmental change, but to date there is an overall lack of evaluation of effectiveness of adaptation action.

Monitoring impacts

Monitoring projects are underway in many parts of the Great Lakes region. These projects and programs are examining a variety of subjects, including biodiversity, regional habitats, and water resources. For example, a project team in Quebec is developing a monitoring system that can detect climate-induced changes in biodiversity at different spatial scales.¹⁶⁶ Superior National Forest,

¹⁶² GLISAclimate <http://www.glisacclimate.org/>

¹⁶³ Adaptation Collaboratory <https://adapt.nd.edu>

¹⁶⁴ Gregg, R. M. (2012). *Integrating Climate Change into Municipal Watershed Management in Ontario* [Case study on a project of Toronto and Region Conservation Authority]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁶⁵ Climate Adaptation Knowledge Exchange (CAKE) www.cakex.org

¹⁶⁶ Development of a Methodology and Sampling Protocol for Monitoring Biodiversity in Relation to Climate Change http://www.ouranos.ca/media/publication/197_PerisNeto2012_webEng.pdf

University of Minnesota, and the U.S. Forest Service Northern Research Station are developing a climate monitoring and assessment project, funded by the American Recovery and Reinvestment Act, aimed at understanding how Minnesota's northeastern forests will respond to changing climate conditions.¹⁶⁷ Finally, the Fond du Lac Band of Lake Superior Chippewa, located in Minnesota, is conducting a monitoring program to inform the tribe about climate-induced changes and trends. Many cultural and natural resources of importance to the tribe have been identified as being vulnerable to climate change, including wild rice beds, fish and moose species, and habitat. The Fond du Lac Environmental Program has engaged in long-term water temperature monitoring since 2001; continuous loggers in the reservation's six primary streams collect water temperature data from early spring to late fall every year. Recognizing that changes in water temperature and hydrology can be strong indicators of climatic changes, the tribe, with the assistance of retired U.S. Geological Survey staff, installed continuous water level loggers in the same six streams to collect hydrologic data in 2010; these loggers record a pressure measurement every 30 minutes. The tribe is using the information collected to inform planning and management decisions.¹⁶⁸

Evaluating planning and management goals

Sustaining Lakes in a Changing Environment (SLICE) is the Minnesota Department of Natural Resources' Section of Fisheries' long-term monitoring program of water chemistry, fisheries, habitat, and other biological and chemical indicators. Information is being gathered to assist in the development of management approaches that include a better understanding of how the state's aquatic ecosystems respond to a variety of stressors, ranging from land use practices to climate change. The first phase of the project (2008-2012) is monitoring processes and exploring drivers of change in water quality and fish habitat condition in 24 sentinel lakes across the state's four predominant ecosystem types. The second phase is slated to begin in 2012 and will examine and apply lessons learned from Phase 1 in order to create a robust, long-term lake monitoring program that includes land use and climate change considerations.¹⁶⁹

¹⁶⁷ Reichenbach, K. (2010). *Superior National Forest Monitors Climate Change Effects Thanks to Recovery Act Funds*. U.S. Forest Service Success Stories, Apr 4, 2010.

www.fs.fed.us/r9/ssrs/story?id=5183%20&%20http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5353905.pdf

¹⁶⁸ Gregg, R. M. (2012). *Integrating Climate Change into Water Quality Monitoring on the Fond du Lac Reservation in Minnesota* [Case study on a project of the Fond du Lac Band of Lake Superior Chippewa]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁶⁹ Hitt, J. L. (2012). *Sustaining Lakes in a Changing Environment (SLICE): A Long-term Monitoring and Evaluation Program* [Case study on a project of the Minnesota Department of Natural Resources]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Policy

The development and implementation of policies related to climate change is critical to adaptation efforts. Climate change will have multilateral, transboundary effects; it will not be confined by political or social boundaries and will therefore require coordinated policy and planning efforts. Developing adaptation plans, creating new or enhancing existing policies, and developing adaptive management strategies are all mechanisms to support adaptation action.

Develop/implement adaptation plans

Adaptation plans typically assess likely climate change impacts, identify goals and measures to build adaptive capacity and limit vulnerability, and establish guidelines to support the implementation of adaptive measures. Governments play important roles in climate change adaptation by coordinating transboundary and multilateral approaches and by mandating action. Adaptation plans are being developed and implemented at all levels of government – federal, provincial/state, tribal, and municipal – in the Great Lakes region.

Federal

At the federal level, Presidential Executive Order 13514 mandates climate change preparedness in federal agency planning and operations across the country.¹⁷⁰ Each federal agency is required to create and implement an agency-specific climate change adaptation plan. In March 2011, the CEQ released the guidance document, *Federal Agency Climate Change Adaptation Planning: Implementing Instructions*.¹⁷¹ Federal agencies will be submitting adaptation plans as part of their Strategic Sustainability Performance Plans in 2012.

Provincial/ State

Provincial and state-level adaptation plans in the region have been created for Ontario,¹⁷² Quebec,¹⁷³ New York,¹⁷⁴ Pennsylvania,¹⁷⁵ and Wisconsin.¹⁷⁶ A statewide plan is in development for Minnesota¹⁷⁷ and, although a full state plan has not been released for Michigan, the state Department of

¹⁷⁰ Gregg 2010: *Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force*

¹⁷¹ White House. (2011). *Federal Agency Climate Change Adaptation Planning: Implementing Instructions*.

http://www.whitehouse.gov/sites/default/files/microsites/ceq/adaptation_final_implementing_instructions_3_3.pdf

¹⁷² Government of Ontario. (2011). *Climate Ready: Ontario's Adaptation Strategy and Action Plan 2011 - 2014*. Toronto, ON.

http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_085423.pdf

¹⁷³ Ministère du Développement durable, de l'Environnement, Faune et des Parcs. (2012). *2013-2020 Government Strategy for Climate Change Adaptation*. http://www.mddep.gouv.qc.ca/changements/plan_action/strategie-adaptation2013-2020-en.pdf

¹⁷⁴ Rosenzweig, C., Solecki, W., DeGaetano, A., O'Grady, M., Hassol, S., & Grabhorn, P. (Eds.). (2011). *Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation*. Synthesis Report. New York State Energy Research and Development Authority (NYSERDA), Albany, New York. <http://www.nysesda.ny.gov/climaid>

¹⁷⁵ Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations (2011).

www.e-library.dep.state.pa.us/dsweb/Get/Document-82988/7000-RE-DEP4303%20combined%20report.pdf

¹⁷⁶ Wisconsin's Changing Climate: Impacts and Adaptation (WICCI). (2011). Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin. http://www.wicci.wisc.edu/report/2011_WICCI-Report.pdf

¹⁷⁷ Gregg, R. M. & Hitt, J. L. (2012). *Climate Change Adaptation Planning at the State Level in Minnesota* [Case study on a project of the Interagency Climate Adaptation Team and the Climate Change Adaptation Working Group]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Community Health released its Climate and Health Adaptation Plan to guide the public health community in responding to climate-related health risks.¹⁷⁸

Tribal

Tribes are also increasing their adaptation planning efforts. For example, the Grand Portage Band of Lake Superior Chippewa Indians, based along Lake Superior in Minnesota, is developing a climate change adaptation and mitigation plan. The plan will include measures to protect water and air quality, forestry, fisheries, and wildlife and the tribe's subsistence lifestyle in a changing climate. Example strategies include monitoring moose migration patterns and associated temperature data in order to identify land use strategies that can protect potential climate refugia; transitioning from a cold water (brook trout) to a cool water (yellow perch, walleye) fishery in a 61-acre inland lake in response to warming lake temperatures that decimated the cold water species (brook trout); assessing the impact of aquatic invasive species; and promoting the use of mixed species rather than monoculture in forestry practices.¹⁷⁹

Municipal

In 2006, former Chicago Mayor Richard M. Daley established a Climate Change Task Force charged with evaluating the potential impacts of climate change and developing a Climate Change Action Plan. After conducting an impacts assessment and risk analyses, the city prioritized environmental and economic impacts and developed adaptation strategies in the Chicago Climate Action Plan. Implemented actions thus far include integration of future climate scenarios into stormwater management and the development of green urban design projects to reduce heat and flooding.¹⁸⁰

Other adaptation plans are being developed to support the resilience of certain places or habitats by collaborative groups. For example, the Indiana Dunes National Lakeshore contracted with the National Parks Conservation Association, The Field Museum of Chicago, and The Eppley Institute for Parks and Public Lands at Indiana University to develop a strategic plan for the park. The partners convened a meeting for more than 25 researchers, scientists, and natural resource managers, during which participants discussed topics including natural resource management, research opportunities, projected climate change impacts to the region, and strategies to include in the plan. The plan, *National Park, Regional Treasure: The Future of Indiana Dunes National Lakeshore*, lays out strategies and recommendations intended to sustain the park over the long term, one of which is to “establish a climate change action and response plan to protect the park resources most at risk.”¹⁸¹ In addition, a Lake Superior Ecosystem Climate Change Adaptation Plan is being developed under the leadership of the Lake Superior Binational Program's Superior Work Group. The plan builds

¹⁷⁸ Michigan Department of Community Health. (2011). Michigan Climate and Health Adaptation Plan: 2010-2015 Strategic Plan http://www.michigan.gov/documents/mdch/MDCH_climate_change_strategicPlan_final_1-24-2011_343856_7.pdf

¹⁷⁹ González-Maddux, C., E.J. Isaac, & Y. Chenaux. (2012). *Grand Portage Band of Lake Superior Chippewa: Creative Solutions for a Changing Environment*. Institute for Tribal Environmental Professionals www4.nau.edu/tribalclimatechange/tribes/docs/tribes_LSchippewa.pdf

¹⁸⁰ Gregg & Hitt 2012: *A Roadmap for Action: The Chicago Climate Action Plan*

¹⁸¹ National Parks Conservation Association, The Field Museum of Chicago, & The Eppley Institute for Parks and Public Lands at Indiana University. (2011). *National Park, Regional Treasure: The Future of Indiana Dunes National Lakeshore* http://www.npca.org/assets/pdf/INDU_Report_Web.pdf

upon the goals outlined in the Lake Superior Lakewide Management Plan to restore and protect the lake's ecosystem, and includes considerations of climate impacts of concern, such as changes in air and water temperatures, precipitation, wind, and ice cover duration and extent. The partners include regional natural resource agencies with management authority for Lake Superior, including federal (e.g., EPA, Environment Canada, U.S. Fish and Wildlife Service), tribal (e.g., Great Lakes Indian Fish and Wildlife Commission, Red Cliff Band of Lake Superior Chippewa, Fond du Lac Band of Lake Superior Chippewa), provincial (Ontario Ministries of Environment and Natural Resources), and state (e.g., Departments of Natural Resources from Michigan, Minnesota, and Wisconsin) entities. The plan's partners are developing actions that reflect the principles of ecosystem-based management. Example adaptation actions under consideration include: (1) employing riparian buffers to mitigate water flows carrying high sediment and pollutant loads after intense precipitation events; (2) retrofitting existing infrastructure to enhance storage capacity to cope with intense storm events; (3) supporting the education and outreach efforts of local Sea Grant programs; (4) developing a localized data system to facilitate information sharing and exchange on climate change impacts to the lake; and (5) enhancing seeding programs to select and plant seeds that are climate-, drought-, and disease-resistant. A draft of the plan has been crafted and must be approved by all partners before it is released.¹⁸²

Create new or enhance existing policies or regulations

Legislation and regulation can mandate action on climate change. Decision makers, managers, and planners may choose to create new frameworks or opt to use existing frameworks within which to support conservation and management efforts. Creating new policies can be both timely and costly, but may be required if the existing structure is lacking. Incorporating future climatic changes and impacts into existing policies and plans, such as those dealing with harvest, critical habitat, species recovery, pollution, or water resources planning, among others, involves examining existing policies and considering how desired outcomes may be affected as the climate changes.

Create new policy

Executive Order 13514 mandates climate change preparedness in federal agency planning and operations. Many agencies are creating new policies and strategies to meet this directive. The U.S. Fish and Wildlife Service and NOAA are jointly spearheading the development of a National Fish, Wildlife, and Plants Climate Adaptation Strategy, which is meant to coordinate natural resource efforts at not just the federal agency level, but also include tribal, state, and local governments, non-governmental organizations, and private sector entities.¹⁸³ A draft strategy was released in January 2012 and included the following goals:

- “Conserve habitat to support healthy fish, wildlife and plant populations and ecosystem functions in a changing climate

¹⁸² Personal communication with L. Hanson, Lake Superior Binational Program Liaison, University of Wisconsin-Superior/Extension, October 22, 2012.

¹⁸³ Gregg 2010: *Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States*

- Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, recreational, and commercial use in a changing climate
- Enhance capacity for effective management in a changing climate
- Support adaptive management in a changing climate through integrated observation and monitoring and use of decision support tools
- Increase knowledge and information on impacts and responses of fish, wildlife and plants to a changing climate
- Increase awareness and motivate action to safeguard fish, wildlife and plants in a changing climate
- Reduce non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate.”¹⁸⁴

The Lake Ontario Lakewide Management Plan (LaMP) Committee commissioned the creation of a conservation strategy in 2006. Over 150 experts from approximately 50 organizations and agencies contributed over the course of four workshops held in 2006 and 2007. The project resulted in the final report – *The Beautiful Lake: A Binational Biodiversity Conservation Strategy for Lake Ontario* (Strategy) – in 2009.¹⁸⁵ The Strategy identifies five primary threats to the region: development, invasive species, dams and barriers, non-point source pollution, and climate change. Recommendation #6 of the Strategy calls for LaMP agencies to plan for and adapt to climate change by establishing ecological corridors and improving connectivity to support species movement across terrestrial and aquatic habitats, and by incorporating climate change into water resources planning and management. Specifically, the Strategy recommends the following “best bet” actions in planning for climate change: (1) conduct bathymetry and topography mapping of critical nearshore habitats, (2) model effects of lower lake levels, and (3) manage streams and rivers using natural hydrologic ranges, especially while assessing the effects of water withdrawals. In April 2011, the Lake Ontario LaMP Work Group released *Implementing a Lake Ontario LaMP Biodiversity Conservation Strategy*, which identifies the recommendations from the Strategy that will be formally adopted. General actions to be implemented include conserving critical habitats and waters, reducing aquatic invasives, and restoring natural hydrology, native communities, and nearshore habitats; the specific climate-related action that will be implemented is improving ecological connectivity and corridors to support species movement and resilience.¹⁸⁶

Enhance existing policy

The City of Ann Arbor, Michigan, is updating both its 2003 Climate Action Plan and its urban forestry plan. The Climate Action Plan is being updated to include more focused mitigation and adaptation strategies. For example, because climate change is expected to lead to more intense

¹⁸⁴ National Fish, Wildlife, and Plants Climate Adaptation Strategy, Public Review Draft. January 2012

http://www.wildlifeadaptationstrategy.gov/pdf/public_review_draft.pdf

¹⁸⁵ Lake Ontario Biodiversity Strategy Working Group. (2009). *The Beautiful Lake: A Binational Biodiversity Conservation Strategy for Lake Ontario*. http://www.epa.gov/glnpo/lakeont/reports/lo_biodiversity.pdf

¹⁸⁶ Lake Ontario LaMP Work Group and Technical Staff. (2011). *Implementing a Lake Ontario LaMP Biodiversity Conservation Strategy* <http://www.epa.gov/glnpo/lakeont/lake-ontario-biodiversity-conservation-strategy-201104.pdf>

storms and precipitation, the city plans to reduce stormwater rates for residents if they install green infrastructure solutions (e.g., rain barrels, porous pavers). The city also created a sustainability framework, which aims to reorganize city goals to foster more integrated planning; included in the framework are 22 adaptation and mitigation goals. The city also worked with GLISA to incorporate climate forecast data into its urban forestry plan. This information is being used to evaluate the impacts of a changing climate on tree species that planners are thinking of planting now with the intent of trying to diversify the forest so that it is more resilient to possible future changes.¹⁸⁷

Water quality in the region has been the subject of several policy initiatives. Lake Champlain, situated between the Green Mountains of Vermont and the Adirondack Mountains of New York, suffers from problematic blue-green algae blooms caused by pollution – specifically excess phosphorus. Climate change impacts including increased precipitation and more intense storms are likely to exacerbate current pollution problems in the lake by increasing the amount of polluted runoff. In response to these threats, the Conservation Law Foundation filed a lawsuit asking the EPA to reverse their approval of the 2002 Total Maximum Daily Load (TMDL) for the lake. In 2011, the EPA overturned the Lake Champlain 2002 TMDL and kicked off a nationwide study of the relationship between potential climatic changes and increasing pollution, as well as how different pollution control techniques work under changing conditions. The results of the study will be used to inform the new TMDL for the lake.¹⁸⁸ At a broader scale, a September 2012 amendment to the Great Lakes Water Quality Agreement (Agreement), a binational accord between the United States and Canada to protect regional water quality, identified climate change as an urgent issue that will affect water quality in the region. Toxins, pollutants, and harmful algal blooms all present threats to water quality and may be exacerbated by climate change. The amendment integrates these concerns into the Agreement and outlines objectives to identify and understand climate change impacts on regional water quality, improve transboundary coordination of knowledge sharing and actions to build adaptive capacity, increase monitoring, and improve analytical tools and models to aid decision making. The Climate Change Annex to the accord recognizes the need for the United States and Canada to consider climate change impacts when implementing all aspects of the Agreement.¹⁸⁹

Develop/implement adaptive management strategies

Adaptive management plays an important role for decision makers looking to overcome the inherent uncertainty of climate change. It is an iterative process, whereby decision makers test hypotheses through monitoring and adjust decisions and actions based on experience and actual changes in order to improve management. This process can either be active (testing multiple options at once to determine the best course of action) or passive (implementing one option and monitoring to determine if adjustments need to be made).

¹⁸⁷ Kershner 2012: *Climate Adaptation in the City of Ann Arbor, Michigan*

¹⁸⁸ Kershner, J. M. (2012). *Incorporating Climate Change into TMDL Decisions for Lake Champlain* [Case study on a project of the Conservation Law Foundation]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁸⁹ Gregg, R. M. (2012). *Addressing Climate Change Impacts in the Great Lakes Water Quality Agreement* [Case study on a project of the U.S. Environmental Protection Agency and the Canadian Ministry of the Environment]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

The Apostle Islands National Lakeshore (APIS) in Wisconsin is integrating climate change throughout its planning and operations. APIS became a member of the National Park Service's Climate Friendly Parks program in March 2008 and is integrating the overall National Park Service Climate Change Response Strategy¹⁹⁰ into sustainability efforts on site. In addition, climate change has recently been added to the APIS General Management Plan, which acts as a guide for park managers to use while making decisions about resource protection, visitor experience and education, and facility development within the park's boundaries. The climate change addition to the plan calls for park staff to use an adaptive management approach in addressing climate change on park lands and to engage in scientific studies and inventories to support decision making.¹⁹¹

The International Upper Great Lakes Study (IUGLS) was established to identify and evaluate potential improvements to outflow regulation of Lake Superior and resulting impacts on water flows, water levels, and associated resources in the Great Lakes region. As part of the plan of study, climate change scenarios and adaptive management will be used to test different regulation techniques. The uncertainty about climate-induced lake level changes in the Great Lakes motivated the IUGLS Study Board to create an Adaptive Management Group to assess vulnerabilities to extreme water levels, identify and address uncertainty, encourage flexible decision making, and seek support for a post-study, long-term monitoring program.¹⁹²

¹⁹⁰ Gregg, R.M. (2010). *Planning for Climate Change in the National Park Service* [Case study on a project of the National Park Service]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/2759> (Last updated December 2010)

¹⁹¹ Gregg, R. M. (2012). *Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin* [Case study on a project of the Apostle Islands National Lakeshore]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁹² Gregg, R. M. (2012). *Addressing Climate Change in the International Upper Great Lakes Study* [Case study on a project of the International Joint Commission]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Natural Resource Management and Conservation

Including adaptation in natural resource management and conservation is necessary in order to address climate change impacts on Great Lakes' ecological functions and services. A range of options exists for managers and conservation practitioners to decrease vulnerability and increase resilience in natural systems. Examples include incorporating climate change into restoration, enhancing connectivity between areas to allow for shifting species movements, reducing local change, and reducing non-climate stressors that may exacerbate the effects of climate change.

Incorporate climate-smart guidelines into restoration

Restoration is a key activity in natural resource management and conservation. Many restoration activities will, in general, enhance the resilience of ecosystems. By considering historical use and future trends in natural systems, practitioners can restore ecological function to promote resilience in a changing climate. The increasingly variable, non-linear, and stochastic nature of climate change requires that practitioners incorporate future conditions into short-, medium-, and long-term restoration planning efforts. Climate-smart restoration requires “defining goals, assessing current status and challenges, identifying and implementing appropriate strategies, and managing and assessing project performance” all in relation to projected climate change scenarios and impacts.¹⁹³

There are a few climate-smart restoration activities occurring in the Great Lakes region. The largest example is the Great Lakes Restoration Initiative (GLRI),¹⁹⁴ a \$475 million multiagency effort led by the EPA, which was created in FY2010 to address serious environmental issues in the region identified in the Great Lakes Regional Collaboration Strategy.¹⁹⁵ The Initiative's Action Plan, which runs through 2014, identifies five priority areas to guide restoration work in the region: Toxic Substances and Areas of Concern, Invasive Species, Nearshore Health and Nonpoint Source Pollution, Habitat and Wildlife Protection and Restoration, and Accountability.¹⁹⁶ The Action Plan identifies climate change as a problem for all five focus areas and determines that “climate change impacts and the needs of the Great Lakes community to adapt to those impacts will be assessed and addressed by GLRI projects and programs where appropriate. To the extent that actions undertaken as part of this Initiative increase ecosystem resiliency, they will also help the Great Lakes ecosystem adapt to climate change.”¹⁹⁷

Local level projects are also being developed. The National Wildlife Federation and EcoAdapt, in collaboration with NOAA, are piloting several restoration projects in Michigan, Ohio, and New York. These projects are applying the climate-smart framework outlined in the *Restoring the Great Lakes' Coastal Future*¹⁹⁸ technical guidance document in project design, implementation, and evaluation. Lessons learned from these pilot projects will be used to inform an update of the

¹⁹³ Glick et al. 2011

¹⁹⁴ Great Lakes Restoration Initiative (GLRI) <http://glri.us>

¹⁹⁵ Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes <http://www.glr.us/strategy.html>

¹⁹⁶ Gregg, R. M. (2012). *Great Lakes Restoration Initiative* [Case study on a project of the Great Lakes Restoration Initiative]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

¹⁹⁷ GLRI Action Plan 2010-2014 [http://www.fws.gov/glri/documents/glri_actionplan\[1\].pdf](http://www.fws.gov/glri/documents/glri_actionplan[1].pdf)

¹⁹⁸ Glick et al. 2011

guidance document.¹⁹⁹ In addition, the Illinois Lake Michigan Implementation Plan, a project of the Illinois Department of Natural Resources, Alliance for the Great Lakes, Chicago Wilderness, and the Biodiversity Project, is creating a framework for the restoration and protection of Lake Michigan's coasts in Illinois that may inform funding priorities for federal, state, and local projects. The project is focusing on invasive species, habitat and ecosystem restoration, priority rivers and lakes, toxins, sustainable development, non-point source pollution, economic development, and climate change. With respect to climate change, both mitigation and adaptation strategies are in development.²⁰⁰

Enhance connectivity and areas under protection

This strategy includes protecting adequate and appropriate space to allow for climate-induced shifts in species ranges and movements, and improving the management of existing protected areas and refugia,²⁰¹ which may be at risk due to erosion and flooding caused by lake level changes and stronger storms in the region. Enhancing connectivity may support species' natural adaptive responses, ecosystem function and resilience, and genetic exchange among populations²⁰²; measures include maintaining or establishing migration corridors to allow for range shifts and species movements. Managers and planners may decide to create new protected areas, increase the size and number of protected areas, or create networks of protected areas in order to facilitate connectivity.

Two entities in Chicago are prioritizing corridors and connectivity. Chicago Wilderness, an alliance of over 250 organizations committed to increasing and maintaining regional biodiversity, launched a Climate Change Task Force to recommend local adaptation and mitigation strategies. The Task Force produced the *Climate Action Plan for Nature*, which targets landscape connectivity as a means to enhance the resilience of local biodiversity; a specific strategy within the plan calls for the modeling of key stream connectivity areas and the strategic removal of barriers to enhance native aquatic species dispersal.²⁰³ The City of Chicago's Natural Environment Adaptation Working Group is also prioritizing the protection and enhancement of connectivity and corridors. The group created a guiding document, which lists the following strategies specific to enhancing connectivity: (1) expanding the Green Infrastructure Vision map²⁰⁴ in order to identify and prioritize key areas of connectivity, (2) protecting buffers and open space, (3) improving existing habitat on publicly-owned properties (e.g., parks, preserves) that act or may act as critical corridors, (4) promoting potential expansion onto private lands (e.g., golf courses, residential yards), and (5) restoring wetlands and other habitats that maximize connectivity.²⁰⁵

In Quebec, a group of researchers led by Laval University and the Ministry of Sustainable Development, Environment, and Parks is creating a process for protected areas planning and

¹⁹⁹ Gregg & Hitt 2012: *The National Wildlife Federation's Climate-Smart Restoration Partnership in the Great Lakes*

²⁰⁰ Illinois Lake Michigan Implementation Plan

https://wiki.epa.gov/watershed2/index.php/Illinois_Lake_Michigan_Implementation_Plan

²⁰¹ Hansen & Hoffman 2010

²⁰² Hansen & Hoffman 2010

²⁰³ Feifel 2012: *The Chicago Wilderness Climate Action Plan for Nature*

²⁰⁴ Chicago Green Infrastructure Vision Map

http://www.chicagowilderness.org/files/4113/3020/2262/TriState_Resource_Rich_Protection_Areas_Map.pdf

²⁰⁵ Gregg & Hitt 2012: *A Roadmap for Action: The Chicago Climate Action Plan*

management that includes the effects of climate change. The pilot areas are two regions along the St. Lawrence River – the Gaspésie and the Mauricie. Researchers are first examining ecosystem vulnerabilities in these areas under different climate scenarios; they then will analyze the adaptive capacity of the existing protected areas network to mitigate these vulnerabilities. The project will result in the development of tools to measure sensitivity and adaptive capacity of protected areas and project leads hope to develop support for the concept of multi-category protected areas as used by the International Union for Conservation of Nature.²⁰⁶ Additionally, researchers from McGill University, Grenoble University, and Montreal University are engaged in a two-year project focused on developing ecological networks in the St. Lawrence River lowlands. Project participants are mapping spatial variation and productivity of forests to identify potential migration corridors that may be resilient to the impacts of climate change and land use pressures (e.g., agriculture, development). Ultimately, this project will provide interactive maps and other detailed information for use by the Quebec Ministry of Sustainable Development, Environment, and Parks and Quebec Ministry of Natural Resources and Wildlife, as well as by local municipalities, non-governmental organizations, and scientists.²⁰⁷ In neighboring Ontario, the Ministry of Natural Resources is considering the means through which the establishment and management of protected areas could be focused on protecting the northern limits of species' ranges in the province.²⁰⁸

Reduce local climate or related change

Reducing local change can help minimize vulnerability in natural systems. This may include maintaining riparian and vegetation cover or reducing deforestation, which in turn can reduce the risk of flooding, erosion, and temperature extremes by providing shoreline stabilization, increasing water retention, slowing water flows and velocity, and increasing direct shading and cooling to support temperature regulation.

The Grand River Conservation Authority (GRCA) manages the water and natural resources in the Grand River Watershed in Southern Ontario. Part of the GRCA's strategy to increase resilience in the watershed includes creating buffers, planting vegetation, restoring wetlands, and enhancing water storage. Riparian buffers provide habitat, reduce erosion, and trap nutrients and sediment runoff thereby enhancing water quality. Planting trees and enhancing wetlands helps to increase available habitat and enhance the ability of the ecosystem to filter and uptake waterborne nutrients and soils while also shading water bodies in order to regulate temperature changes.²⁰⁹

The Chicago Wilderness *Climate Action Plan for Nature: Community Action Strategies* provides examples of how residents can help mitigate and adapt to climate change. One strategy is to create climate-

²⁰⁶ Adaptation of the Design and Management of Quebec's Network of Protected Areas for Climate Change http://www.ouranos.ca/media/publication/199_BelBra2012_webEng.pdf

²⁰⁷ Monteregie Connection, Designing Ecological Networks for Climate Change <http://www.monteregieconnection.com/designing-ecological-networks-for-climate-change.html>

²⁰⁸ Feifel, K. M. (2012). *Adapting to Climate Change in Ontario Parks* [Case study on a project of the Ontario Ministry of Natural Resources]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

²⁰⁹ Farwell, J., D. Boyd, & T. Ryan. (2008). *Making Watersheds More Resilient to Climate Change: A Response in the Grand River Watershed, Ontario Canada*. Grand River Conservation Authority. <http://www.grandriver.ca/AboutGrand/ClimateChange08.pdf>

friendly gardens and lawns to enhance resilience. The document encourages gardeners to maintain trees and shrubs that can provide shade and sequester carbon.²¹⁰ Similarly, the Huron River Watershed Council's Stream Buffer Initiative encourages local residents to plant buffers on streamside/lakeside property. The Council created a model buffer ordinance with support from the EPA and Michigan Department of Environmental Quality, which has been adopted by two local townships (Scio and Green Oak). The ordinance provides recommendations on permitted uses and activities within buffer zones, buffer width and zoning, and maintenance requirements.²¹¹

Urban forests are increasingly used for mitigation and adaptation purposes. In the City of Chicago, there have been increased efforts to establish urban tree canopy in order to mitigate increasing temperatures and stormwater management issues. The Chicago Trees Initiative has updated its planting lists to include trees that will be more likely to survive in a warmer climate. Southern tree species that are acclimated to warmer temperatures, such as swamp oaks, have been added to list, while the white oak, the state tree of Illinois, is no longer included.²¹²

Reduce non-climate stressors likely to interact with climate change

Numerous non-climate stressors already affect the Great Lakes, which may make the region more vulnerable to climate change. The cumulative effects of stressors, such as water withdrawals, pollution, and non-native or invasive species, reduce the overall resilience of natural systems. Examples of reducing non-climate stressors likely to interact with climate change include managing water withdrawals, reducing pollution, and reducing the presence and extent of invasive and non-native species.

Water withdrawals

Lake levels in the Great Lakes region are established through the “combined influence of precipitation (the primary source of natural water supply to the Great Lakes), upstream inflows, groundwater, surface water runoff, evaporation, diversions into and out of the system, consumptive use, dredging, and water level regulation.”²¹³ It has been estimated that less than one percent of the water within the basin can be renewed each year by precipitation, surface water runoff, and groundwater recharge.²¹⁴ Therefore, water withdrawals and diversions are major issues in the Great Lakes region. The Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement and the Great Lakes-St. Lawrence River Basin Water Resources Compact are two frameworks created to protect the region's water resources by limiting water diversions in both quantity and purpose (e.g., diversions to support enhancing public water supply are supported) and limiting water withdrawals through water conservation and regulatory programs.²¹⁵

²¹⁰ Feifel 2012: *The Chicago Wilderness Climate Action Plan for Nature*

²¹¹ Gregg 2012: *Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed*

²¹² Gregg & Hitt 2012: *A Roadmap for Action: The Chicago Climate Action Plan*

²¹³ International Joint Commission (IJC). (2000). Protection of the Waters of the Great Lakes.

<http://www.ijc.org/php/publications/html/finalreport.html>

²¹⁴ IJC 2000

²¹⁵ Council of Great Lakes Governors <http://www.cglg.org/projects/water/legal.asp>

Reducing pollution

The Maumee River watershed in Ohio is the largest in the Great Lakes region; it suffers from multiple sources of pollution, including agricultural runoff, combined sewer overflows, and other non-point sources, which are causing harmful algal blooms and reducing fish populations in the river and Lake Erie. More intense and frequent storms expected with climate change will exacerbate these existing problems. Researchers at Ohio State University and Case Western Reserve University received funding to examine how land use practices in the watershed affect the water quality of Lake Erie and how people's perceptions of the lake influence those practices. Project leads are conducting focus groups on people's perceptions and behavior and developing decision-making models to identify upstream practices that can minimize agricultural runoff and resulting water quality degradation.²¹⁶ At the local level, the City of Milwaukee, Wisconsin, is employing swales and rain gardens to mitigate stormwater runoff in the hopes of reducing negative effects on water quality.²¹⁷

Non-native/invasive species

Non-native/invasives species include plants and animals that have the potential to alter food webs, biodiversity, and ecosystem condition. Two projects in Michigan and Ohio are addressing invasive plant species. In 2009, the Huron Pines Resource Conservation and Development Council (Huron Pines) published the Northeast Michigan Coastal Stewardship Project report, which recommended that Huron Pines take the lead on addressing invasive species removal (e.g., *phragmites australis*) given that climate change could improve conditions for invasives in the future. Huron Pines has since developed a long-term, sustainable program for *phragmites australis* removal by creating a Cooperative Weed Management Area,²¹⁸ educating and engaging local government officials and property owners about invasive species removal, and developing an early detection and rapid response system. The program has also enabled staff to discuss emergent wetland vegetation and climate change with landowners, which has led to many owners maintaining native wetland vegetation to increase the long-term resilience of Michigan's coast.²¹⁹ In Ohio, managers of the Ottawa National Wildlife Refuge on Lake Erie are working with the Ohio Division of Wildlife to eradicate and minimize the spread of invasive species such as purple loosestrife and *phragmites*. Climate change is predicted to increase suitable habitat for these species, which threaten migrating birds and wildlife that depend on native vegetation and marshland habitat for survival. Local researchers are also aiding managers by creating visualization tools that show areas of "new" shoreline as a result of climate change, which will facilitate planning efforts.²²⁰

Pennsylvania Sea Grant conducted a project to examine the potential increase in habitat suitability for the introduction, distribution, and establishment of aquatic invasive species in a changing climate. Some studies estimate that increased temperatures will allow some species to expand their ranges. Project staff applied three climate scenarios in order to identify and prioritize species with

²¹⁶ Kershner, J. M. (2012). *Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio* [Case study on a project of Ohio State University]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

²¹⁷ City of Milwaukee, Wisconsin. Managing Your Stormwater. <http://city.milwaukee.gov/ManagingYourStormwater>

²¹⁸ Northeast Michigan Cooperative Weed Management Plan http://www.huronpines.org/media/projects/media/cwma_signed.pdf

²¹⁹ Huron Pines Invasive Phragmites Control <http://www.huronpines.org/projectinfo.asp?pit=pv&pid=17>

²²⁰ Koslow 2010

the highest potential for range expansion; about 50 fish, plant, and invertebrate species not currently found in Pennsylvania were identified as potential invaders and four were identified as “high risk.” A framework was created to assist managers looking to develop proactive control and management techniques for addressing aquatic invasive species establishment.²²¹

²²¹ Gregg 2012: *Pennsylvania Sea Grant's Climate Change Outreach and Research Projects*

Infrastructure, Planning, and Development

This category deals with climate-related threats to water resources and communities from increased temperatures, storm frequency and intensity, changes in precipitation, and increased flooding and erosion. Planners need to identify and assess vulnerabilities and develop adaptive responses to protect infrastructure and public health and safety, all while limiting environmental damage. Strategies within this category include improving existing or designing new infrastructure to withstand the effects of climate change, incorporating climate change into community and land use planning, creating or modifying development measures (e.g., removing shoreline hardening, encouraging low impact development), and developing disaster preparedness plans and policies.

Make infrastructure resistant or resilient to climate change

Incorporating climate change into the operations, retrofitting, or development of existing and new infrastructure and plans dealing with water supply, stormwater, and wastewater systems may help limit the effects of climate change on water resources. Changes in temperature and the intensity of storms and precipitation patterns will cause lake level changes, erosion, and flooding that will in turn increase the risk of infrastructure damage or malfunctions, decreased water quality, and fluctuating water supply as the magnitude, frequency, and duration of water flows changes. Climate change needs to be integrated into both water resources infrastructure and management. Water resources infrastructure serves to convey, store, and protect water.²²² Conveyance (e.g., channels, pipes), storage (e.g., reservoirs), and protective (e.g., levees, dams) measures all serve to manage water at specified levels; climate-driven changes will create highly variable conditions that will complicate the business-as-usual (or stationarity-driven²²³) approach commonly employed by water management authorities. Integrated Water Resources Management (IWRM) is needed to effectively respond to climate change. The Global Water Partnership defines IWRM as “a process which promotes the coordinated development and management of water, land, and related resources in order to [maximize] economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment.”²²⁴ This strategy includes recognizing the linkages between land and water use, water quantity and quality, information exchange and decision making, and demand and supply.^{225,226}

The Natural Resources Defense Council released a report evaluating climate and water planning activities in U.S. states in 2012.²²⁷ States were ranked in four categories:

²²² WICCI Stormwater Working Group Report <http://www.wicci.wisc.edu/report/Stormwater.pdf>

²²³ Milly, P.C.D., J. Betancourt, M. Falkenmark, R.M. Hirsch, Z.W. Kundzewicz, D.P. Lettenmaier, & R.J. Stouffer. (2008). Stationarity is dead: Whither water management?. *Science*, 319, 573-574.

²²⁴ Global Water Partnership. What is IWRM? <http://www.gwp.org/The-Challenge/What-is-IWRM/>

²²⁵ Brekke, L.D., J.E. Kiang, J.R. Olsen, R.S. Pulwarty, D.A. Raff, D.P. Turnipseed, R.S. Webb, & K.D. White. (2009). Climate change and water resources management—A federal perspective: U.S. Geological Survey Circular 1331. <http://pubs.usgs.gov/circ/1331>

²²⁶ Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Doll, P. Kabat, B. Jimenez, K.A. Miller, T. Oki, Z. Sen, & I.A. Shiklomanov. (2007). Freshwater resources and their management. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210. <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter3.pdf>

²²⁷ Chou, B. (2012). *Ready or not: An evaluation of state climate and water preparedness planning*. Washington, DC: The Natural Resources Defense Council.

- Category 1: An integrated adaptation plan has been created that addresses water resources, which the state is working to implement.
- Category 2: Some state agencies are addressing climate change impacts on water resources but the approaches are not coordinated or guided by a comprehensive strategy.
- Category 3: There is limited attention given to climate change impacts on water resources in state programs and policies.
- Category 4: The state has not yet addressed adaptation for water resources.

In the Great Lakes region, the states are ranked as follows: Category 1 (Pennsylvania, Wisconsin, New York); Category 2 (Minnesota, Michigan); Category 3 (Illinois); and Category 4 (Indiana, Ohio).

Activities to study, evaluate, and implement changes in water resources infrastructure and management in relation to climate change are taking place throughout the Great Lakes region, including Minnesota, Illinois, Ontario, and Ohio. The Minnehaha Creek Watershed Stormwater Adaptation Study [or the Weather Extreme Trends (WET) Project] aims to assist managers to cope with the inherent uncertainty in climate projections by identifying measures to adapt systems to future conditions. Projections show an increase in frequency and severity of storms across Minnesota; existing stormwater management systems may not be able to handle future runoff and flow, which will result in infrastructure and property damage, water quality degradation, and habitat loss. Project leads are examining land use and precipitation trends, evaluating existing stormwater systems, identifying adaptation measures, and leading a community-driven process to develop adaptation plans for stormwater systems in the watershed.²²⁸

The Illinois State Water Survey, Illinois Department of Natural Resources' Office of Water Resources, and the Illinois State Geological Survey collaborated on a project to examine historical climate information and future climate scenarios in order to improve understanding of and support planning for future supply and demand of regional water resources. The project examined climate impacts (e.g., temperature, precipitation) on surface and groundwater resources and resulting complications for sustainable water supply planning in the state. Key recommendations to support sustainable water supply planning in the state included evaluating existing facilities to cope with drought conditions and building historic drought and climatic data into water supply scenarios to enhance facility resilience.²²⁹

A 2007-2008 joint project between Queen's University and Mississippi Valley Conservation examined the effects of climate change and adaptation responses on southern Ontario's fish, fisheries, and water resources. One component of the project was dedicated to examining water resources management responses to climate change. This subproject examined the vulnerability of

<http://www.nrdc.org/water/readiness/files/Water-Readiness-full-report.pdf>

²²⁸ Hitt, J. L. (2012). *Weather – Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study* [Case study on a project of the Minnehaha Creek Watershed District]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

²²⁹ Gregg, R. M. & Hitt, J. L. (2012). *Water Supply Planning for Illinois* [Case study on a project of the Illinois State Water Survey]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

the Mississippi River Water Management Plan and its operations to climate change and provided recommendations to improve water management planning in the region to address climate change impacts. This study was undertaken to downscale climate predictions of precipitation and temperature to the watershed level, quantify climate change impacts on the water budget, and simulate stream flows and water levels through modeling to inform future management decisions. Researchers recommended the incorporation of climate predictions into water management planning, increased communication and education to water resource users, increased reservoir storage capacity, and enhancement of integrated watershed management.²³⁰

The Northeast Ohio Regional Sewer District has implemented Project Clean Lake to address water quality issues caused by raw sewage that overflows into the environment during rain events – a problem likely to be exacerbated by climate change. The Project Clean Lake program includes construction of seven new gray infrastructure tunnels to increase storage capacity for combined sewage, improvements to treatment plant infrastructure, and installation of green infrastructure to help keep stormwater from entering the combined sewer system. The District is also working with the City of Cleveland to assess the use of vacant lots for green infrastructure projects to reduce the long-term cost of the program while enhancing neighborhoods, providing economic development opportunities, and rebuilding the community.²³¹

Community planning (developing climate-smart communities)

International and national actions are needed to address broad climate change policies and steps taken at these levels may motivate local action. Local planning and engagement are key to adaptation implementation. External partners such as Michigan Sea Grant, Michigan State University, the Model Forest Policy Program, New York state agencies, and the Huron River Watershed Council have supported adaptation planning in Great Lakes communities.

Michigan Sea Grant is working with the Spring Lake village and township to assess the impacts of climate change on stormwater runoff, identify management strategies for Great Lakes communities, and develop a guide for stormwater best management practices under altered regional climate conditions.²³² A team of Michigan State University Extension specialists and educators has received funding from GLISA to collaborate with GLISA researchers, key decision makers, and stakeholders in two local governments to increase community resilience to climate variability. The project, *Adapting to Climate Change and Variability: Planning Tools for Michigan Communities*, will incorporate climate variability and adaptation strategies into local land use master plans and policies and create an assessment tool that can be used by other communities throughout Michigan.²³³

²³⁰ Gregg, R. M. (2012). *Fish, Fisheries, and Water Resources: Adapting to Ontario's Changing Climate* [Case study on a project of Queen's University and Mississippi Valley Conservation]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

²³¹ Feifel, K. M. (2012). *Project Clean Lake: Updating Cleveland's Sewer Systems to Reduce Stormwater Overflows* [Case study on a project of the Northeast Ohio Regional Sewer District]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

²³² Feifel, K. M. (2012). *Rein in the Runoff: Michigan's Spring Lake Stormwater Management Project* [Case study on a project of Michigan Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

²³³ Personal communication with J.E. Doll, W.K. Kellogg Biological Station, Michigan State University, September 2012

The Superior Watershed Partnership partnered with the Model Forest Policy Program to help Alger County, Michigan adapt to the impacts of climate change. Working within the Climate Solutions University, a web-based forest and water climate adaptation training program, the Superior Watershed Partnership developed the plan through a four-step process including: (1) creating a local climate action team; (2) assessing local conditions for resource vulnerabilities and action opportunities; (3) developing strategies and recommendations for climate adaptation; and (4) implementing and monitoring climate adaptation plans.²³⁴

The New York Climate Smart Communities program is a partnership created in 2009 between local communities and five state agencies – the Departments of Environmental Conservation, State, and Transportation, and the Energy Research and Development Authority and Public Service Commission. It combines mitigation and adaptation responses to limit or eliminate the effects of climate change on local communities (e.g., towns, villages, cities, counties). The program provides communities with technical support and guidance; as part of the program, each community must adopt a model pledge to reduce greenhouse gas emissions and prepare for climate change. The Department of Environmental Conservation recently released the *Climate Smart Communities Guide to Local Action*,²³⁵ which provides step-by-step guidance to assist communities; for example, the guide provides information on how to conduct emissions inventories, develop climate action plans, and reduce energy needs. Communities in six counties in the Great Lakes region have joined the program; they include Erie County (Town of Amherst, Town of Brant, Town of Evans, Village of East Aurora), Jefferson County (Village of West Carthage), Monroe County (City of Rochester, Town of Irondequoit), Niagara County (Town of Lewiston, Town of Porter, Town of Royalton, Town of Somerset), Oswego County (City of Oswego, County of Oswego), and Saint Lawrence County (City of Ogdensburg, Village of Norwood).²³⁶

The Huron River Watershed Council (HRWC), based in Ann Arbor, Michigan, is working on a collaborative project to develop Climate-Resilient Communities in the region. This is a community project driven and supported by local funding sources. Focusing on three key sectors – water infrastructure, in-stream flows, and natural infrastructure – the HRWC, along with GLISA and the River Network, is convening scientists, engineers, planners, and managers to collaborate on climate change adaptation strategy development. Through a series of facilitated meetings, participants are gaining access to and understanding of the best available climate science, exploring adaptive capacity, sharing best practices and case studies of adaptation action, and identifying needs and opportunities (e.g., green infrastructure, education, infrastructure retrofitting). Each of the three sectors have created specific groups within which to brainstorm strategies and develop actions for implementation. HRWC and its partners also plan to evaluate the project and lessons learned; this is

²³⁴ Gregg, R. M. (2012). *Developing a Climate Change Adaptation Plan for Forest and Water Resources in Alger County, Michigan* [Case study on a project of the Superior Watershed Partnership and Land Trust]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

²³⁵ New York Climate Smart Communities Guide to Local Action <http://www.dec.ny.gov/energy/50845.html#Climate>

²³⁶ Gregg, R. M. (2012). *New York's Climate Smart Communities Program* [Case study on a project of New York Department of Environmental Conservation]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

a model approach that may be more broadly applicable to other watersheds throughout the country.²³⁷

Create or modify shoreline management measures

There are four primary shoreline management measures employed to address erosion issues – hard structures (e.g., rip rap, bulkheads), soft stabilization (e.g., living shorelines), hybrid (hard plus soft measures), and policy and planning techniques (e.g., managed retreat, setbacks).²³⁸ Hard structures used in shoreline armoring can require the removal of native vegetation and soils; constructing “living” shorelines meanwhile, involves the planting of vegetation to stabilize banks and trap sediments from runoff. Managed retreat and relocation of communities and infrastructure may be required in more extreme cases. Green infrastructure²³⁹ and low impact development²⁴⁰ practices are also being used, which mimic and support the use of natural features, including permeable surfaces, swales, water retention ponds, green roofs, urban forestry, green alleys and streets, rain barrels, and rain gardens; these techniques can moderate increases in temperature and changes in precipitation patterns.

In Detroit, climate change is likely to bring more intense rainstorms, resulting in more flooding and sewage overflows polluting the Great Lakes. In response, the Sierra Club Great Lakes Program decided to investigate green infrastructure solutions – everything from rain barrels and cisterns to rain gardens and constructed wetlands to landscaping with native vegetation and using permeable pavers – that create rainwater filtration at the surface before water enters the sewer system. The Sierra Club has been working to educate community groups and residents throughout Detroit about climate change, its impacts on sewer overflows, green infrastructure methods that individuals and communities can employ, and how green infrastructure can help reduce sewer overflows as well as save residents money on water bills.²⁴¹

Other groups have taken integrated planning approaches. For example, in 2006, the Ohio Lake Erie Commission (OLEC) launched the Balanced Growth Program, a voluntary, incentive-based initiative to manage growth in the Lake Erie watershed. The program develops watershed-based planning partnerships among local communities, provides guidance on land use practices for minimizing impacts on water quality, and enables communities to build adaptive capacity to climate change. The OLEC has also updated the Lake Erie Protection and Restoration Plan, which now recognizes climate change as a priority area and sets a goal to help watershed communities and landowners understand and prepare for climate change impacts. To facilitate this goal, members of

²³⁷ Gregg 2012: *Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed*

²³⁸ NOAA Shoreline Management: Alternatives to Hardening the Shore <http://coastalmanagement.noaa.gov/shoreline.html>

²³⁹ Center for Clean Air Policy. (2011). *The Value of Green Infrastructure for Urban Climate Adaptation*.

http://www.ccap.org/docs/resources/989/Green_Infrastructure_FINAL.pdf

²⁴⁰ U.S. Environmental Protection Agency, Low Impact Development <http://water.epa.gov/polwaste/green/>

²⁴¹ Kershner, J. M. (2012). *Using Green Infrastructure to Prevent Sewage Overflows in Detroit* [Case study on a project of the Sierra Club Great Lakes Program – Michigan]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

the Balanced Growth Technical Advisory Committee have developed model legislation for shoreline development that recognizes climate change impacts.²⁴²

Develop disaster preparedness plans and policies

Climate change may exacerbate natural disasters in the Great Lakes region, including droughts, floods, severe storms, and extreme heat that will harm people, property, and water resources. Disaster preparedness and mitigation plans can help communities identify risks and develop response and recovery options. There are few examples from the region that incorporate climate change impacts. The Bay-Lake Regional Planning Commission (RPC) provides hazard mitigation planning support to the coastal communities along Lake Michigan in Wisconsin. The RPC incorporated climate change issues into *A Guide for Hazard Mitigation Planning for Wisconsin Coastal Communities*²⁴³ and began educating managers and planners on climate change impacts. The guide encourages practitioners to develop multi-hazard mitigation plans that integrate the projected increases in the intensity and frequency of events, such as temperature extremes, storms, floods, and droughts.²⁴⁴ Leelanau County, Michigan's Natural Hazards Mitigation Plan lists the projected climate-driven changes in rainfall, evaporation, and groundwater recharge rates as important natural hazards to address. The strategies listed within the plan include reducing greenhouse gas emissions, minimizing existing stressors on water resources and the natural environment, and enhancing emergency preparedness efforts (e.g., public health response and warning, flood control infrastructure).²⁴⁵

²⁴² Ohio Balanced Growth Program <http://www.balancedgrowth.ohio.gov/balancedgrowthplanning.aspx>

²⁴³ Bay-Lake RPC. (2007). *Guide for Hazard Mitigation Planning for Wisconsin Coastal Communities*.

www.baylakerpc.org/media/46893/coastal%20hazards%20planning%20guide_june%202007.pdf

²⁴⁴ Gregg, R. M. (2012). *Climate Change Mitigation and Adaptation Planning in Wisconsin's Lake Michigan Coastal Communities* [Case study on a project of the Bay-Lake Regional Planning Commission]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

²⁴⁵ Northwest Michigan Council of Governments. (2006). Natural Hazards Mitigation Plan: Leelanau County, Michigan. Traverse City, Michigan. www.leelanau.cc/downloads/hazard_mitigation_plan_leelanau_1.doc

Regional Challenges and Opportunities

Climate change is not a problem of the future – it is a pressing dilemma that faces all of us every day. In the Great Lakes region, there are many individuals, organizations, and agencies interested and/or engaged in climate change adaptation efforts. Most efforts have focused on building capacity of practitioners to understand, address, and plan for climate change. There are fewer examples of adaptation being implemented on the ground. Survey participants listed a number of challenges to taking action; some examples include:

- Lack of financial capacity, including limited funding to support staff time to initiate or sustain climate change efforts within organizations or to coordinate multi-sector efforts (e.g., Michigan Climate Coalition, WICCI).
- Lack of institutional capacity, including limited staff knowledge and/or resources to support internal and coordinated efforts.
- Lack of political will and mandate for action, including the inability to sustain interest in climate change over time and with constantly pressing other issues and priorities (e.g., economic problems).
- Limited guidance on how to apply the wide variety of information available on climate change impacts and adaptation.
- Limited information sharing between and across agencies and organizations.

Survey participants also listed the following activities that would help support existing or promote future adaptation initiatives:

- Tracking legal and regulatory frameworks at local, state, regional, national, and international levels to guide climate change action.
- Identifying the most applicable data, models, resources, and tools that can support adaptation efforts at different scales and for different sectors (e.g., what is an appropriate adaptation planning tool for city water utilities?).
- Translating climate change science and adaptation information for both practitioners and laypeople.

Many of the challenges and needs mentioned by survey participants are not uncommon,^{246,247,248} however, there are also many opportunities to enhance existing or create new adaptation initiatives. These include:

²⁴⁶ Glick, P., A. Staudt, & B. Stein. (2009). *A New Era for Conservation: Review of Climate Change Adaptation Literature*. National Wildlife Federation. 54p. <http://www.cakex.org/virtual-library/788>

²⁴⁷ Kareiva, P., C. Enquist, A. Johnson, S.H. Julius, J. Lawler, B. Petersen, L. Pitelka, R. Shaw, & J.M. West. (2008). Synthesis and Conclusions. In: Preliminary review of adaptation options for climate-sensitive ecosystems and resources. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Julius, S.H., J.M. West (eds.), J.S. Baron, B. Griffith, L.A. Joyce, P. Kareiva, B.D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott (Authors)]. U.S. Environmental Protection Agency, Washington, DC, USA, pp. 9-1 to 9-66.

²⁴⁸ Gregg et al. 2011

- **Enhancing collaborative efforts.** Some cities and states/provinces are further ahead than others in the region on climate change adaptation. Enhancing collaboration and coordination can build capacity for adaptation through the sharing of resources (technical, financial), tools, and knowledge.
- **Increasing knowledge and information translation.** Climate change science and adaptation information can be overwhelming to process and apply for many practitioners. Translation and education are needed in order to help these practitioners overcome analysis paralysis so that adaptation can be integrated and applied in decision making.
- **Increasing knowledge sharing.** A lot of effort has been made to facilitate information development and dissemination in the Great Lakes region. Increasing the mechanisms through which this knowledge is shared could be enhanced; GLISAclimate and the Adaptation Collaboratory are two such means. Engaging in and sharing local knowledge on more national and international websites, such as CAKE and weADAPT, would promote adaptation activities in the Great Lakes; users could also apply lessons learned and case studies from other regions gathered through these resources to local efforts in the Great Lakes region.
- **Developing vulnerability maps.** Because the effects of climate change will vary across space, vulnerability assessments and adaptation strategies can be improved by accounting for the specific threats posed to a target area. Vulnerability maps compare scenarios of future climate changes, such as changes in temperature, vegetation patterns, or hydrology, with contemporary layers, such as the locations of priority habitats, focal species distributions, or current land use practices. These ‘climate-informed’ maps help identify those areas likely to change more and those likely to change less, as well as identify where key resources are likely to be most affected by changing climate conditions. Combined mapping of valued resources and climate-related impacts also allows managers and planners to target protection and intervention efforts in more informed ways, including developing adaptation strategies and identifying where, when, and how to implement those strategies for effective resource management. Similar efforts have been completed for terrestrial, freshwater, and coastal marine habitats in western Washington.^{249,250}
- **Engaging in other national or international efforts.** For example, the Water Utility Climate Alliance was created in 2007 to help water and wastewater utilities prepare for climate change. Current members include the Central Arizona Project, Denver Water, the Metropolitan Water District of Southern California, New York City Department of Environmental Protection, Portland Water Bureau, San Diego County Water Authority, San Francisco Public Utilities Commission, Seattle Public Utilities, Southern Nevada Water Authority, and Tampa Bay Water. These agencies work collaboratively on ways to address

²⁴⁹ Kershner, J., E. Mielbrecht, M. Koopman, & J. Leonard. (2012). *A Climate-Informed Conservation Blueprint for the Greater Puget Sound Ecoregion*. Prepared by EcoAdapt and the Geos Institute for the Sierra Club. Bainbridge Island, WA. <http://ecoadapt.org/data/library-documents/Puget%20Sound%20Climate-Blueprints%20Final%207March12.pdf>

²⁵⁰ From the Mountains to the Sea: Applying the Yale Framework in Puget Sound <http://www.databasin.org/yale/pilots/ecoadapt>

climate change impacts on water utilities.²⁵¹ Similar utilities in the Great Lakes region could engage in this effort. Great Lakes states could also join the StormSmart Coasts Network, which provides local coastal communities and decision makers with up-to-date and relevant information on storms, flooding, and climate change. Information is tailored to each individual state and presents details to support preparation and recovery efforts before, during, and after storms.²⁵²

- **Enhancing monitoring and evaluation.** Monitoring and evaluation are needed to identify climate-driven changes and to test adaptation efficacy, specifically what is and is not working so that approaches can be modified. While some evaluation happens on an *ad hoc* basis, many practitioners are in need of a specific climate change adaptation monitoring and evaluation decision support tool; some efforts to meet this need include the Climate-Eval website²⁵³ from the Global Environment Facility and a monitoring toolkit from EcoAdapt that is in development.

²⁵¹ Feifel, K. & Gregg, R. M. (2010). *Water Utility Climate Alliance* [Case study on a project of the Water Utility Climate Alliance]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/1018> (Last updated July 2011)

²⁵² Gregg, R. M. (2010). *The National StormSmart Coasts Network: Linking Coastal Decision Makers to Resources* [Case study on a project of StormSmart Coasts]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/973> (Last updated April 2010)

²⁵³ Climate-Eval www.climate-eval.org

Conclusion

Global climate change is having and will continue to have short- and long-term effects on the Great Lakes region. Adaptation approaches are key to helping the region prepare for and respond to climate change impacts by decreasing vulnerability and increasing resilience. Some of the strategies presented in this report are more feasible than others for different individuals and organizations; planners, managers, and other practitioners will have to make decisions based on cost-benefit and feasibility analyses of different adaptation options depending on their political, institutional, technical, and financial capacity. Advancing climate change adaptation in the Great Lakes region will require support for implementation and the evaluation of effectiveness.

Appendices

- A. Climate Change Adaptation Literature
- B. State of Adaptation Methodology
- C. Adaptation Case Studies from the Great Lakes Region (by strategy)
- D. Adaptation Case Studies Compendium

A. Climate Change Adaptation Literature

Hansen, L.J., J.L. Biringer, & J.R. Hoffman (eds). (2003). *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems*. World Wildlife Fund (WWF).

http://assets.panda.org/downloads/buyingtime_unfe.pdf

Hansen, L.J. & J.R. Hoffman. (2010). *Climate Savvy: Adapting Conservation and Resource Management to a Changing World*. Island Press, Washington DC. <http://www.amazon.com/Climate-Savvy-Adapting-Conservation-Management/dp/159726685X>

The Heinz Center. (2008). *Strategies for Managing the Effects of Climate Change on Wildlife and Ecosystems*. Washington, DC, 43 pp.

http://www.heinzctr.org/Major_Reports_files/Strategies%20for%20Managing%20the%20Effects%20of%20Climate%20Change%20on%20Wildlife%20and%20Ecosystems.pdf

Heller, N.E. & E.S. Zavaleta. (2009). *Biodiversity management in the face of climate change: A review of 22 years of recommendations*. *Biological Conservation* 142:14-32.

Intergovernmental Panel on Climate Change. (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability*

http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm

Julius, S.H. & J.M. West (eds). (2008). *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington, D.C.

Lawler, J.J. (2009). Climate change adaptation strategies for resource management and conservation planning. *The Year in Ecology and Conservation Biology* 1162: 79-98.

National Research Council. (2010). *Adapting to the Impacts of Climate Change*. National Academies Press, Washington, DC.

Richardson, G. R. A. (2010). *Adapting to Climate Change: An Introduction for Canadian Municipalities*. Natural Resources Canada, Ottawa, Ontario.

http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/earth-sciences/files/pdf/mun/pdf/mun_e.pdf

U.S. Global Change Research Program. (2008). *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources* (SAP 4.4). U.S. Environmental Protection Agency, Washington, DC

<http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=180143>

B. State of Adaptation Methodology

With the support of the Charles Stewart Mott Foundation, this project was initiated to survey, inventory, and, where possible, assess past, current, and proposed climate change adaptation activities and projects in the Great Lakes region related to freshwater resources. In order to conduct this project, we applied our State of Adaptation methodology.

The primary outputs of the State of Adaptation Program are synthesis reports, such as this one, and case studies. In addition, we supply the information collected on projects, people, and organizations into the Case Studies, Virtual Library, Directory, and Tools sections of the Climate Adaptation Knowledge Exchange (CAKE; www.cakex.org).

The steps involved in creating these products include:

1. Conducting a literature search of relevant information on climate change impacts and adaptation.
2. Contacting identified individuals who have or are likely to have adaptation projects.
3. Writing case study summaries of relevant adaptation activities and projects.
4. Creating a synthesis of all information collected.

Literature search

EcoAdapt scientists conducted a review of the most up-to-date literature on climate change impacts and adaptation in the Great Lakes region, including assessments, agency and non-governmental reports, and scientific literature.

Interviews and surveys

A contact list was compiled of organizations and individuals who were believed to have adaptation projects and/or who were likely to know about adaptation initiatives in the region; this list grew with subsequent referrals to other individuals during interviews. In addition, announcements of the survey were distributed through relevant newsletters and listservs. We applied a combined approach of a structured online survey questionnaire and semi-structured interviews conducted by EcoAdapt scientists; individuals were provided with a choice between completing the online survey or being contacted for an interview. A unified set of questions and an interview guide were created and a coding scheme for answers was designed in order to make tracking and cross-referencing possible. In order to analyze our findings for this survey, we grouped adaptation strategies as they relate to freshwater resources (and in some cases, at the freshwater/terrestrial interface) by the following categories – *Capacity Building, Policy, Natural Resource Management and Conservation, and Infrastructure, Planning, and Development*. Adaptation strategies include:

1. Capacity Building
 - a. Design or reform institutions
 - b. Conduct research, studies, and assessments
 - c. Conduct training and planning exercises
 - d. Increase/improve public awareness, education, and outreach efforts
 - e. Create/enhance resources and tools
 - f. Monitor climate change impacts and adaptation efficacy

2. Policy
 - a. Develop/implement adaptation plans
 - b. Create new or enhance existing policies or regulations
 - c. Develop/implement adaptive management strategies

3. Natural Resource Management and Conservation
 - a. Incorporate climate-smart guidelines into restoration
 - b. Enhance connectivity and areas under protection
 - c. Reduce local climate or related change
 - d. Reduce non-climate stressors likely to interact with climate change

4. Infrastructure, Planning, and Development
 - a. Make infrastructure resistant or resilient to climate change
 - b. Community planning (developing climate-smart communities)
 - c. Create or modify shoreline management measures
 - d. Develop disaster preparedness plans and policies

Case studies

EcoAdapt staff identified potential projects to be written as case study examples through interviews and surveys and reviews of online resources and publications. Over 100 examples of freshwater-related adaptation activities in the Great Lakes region were uncovered during this project and 57 were chosen to be developed into case studies. All of the case studies follow the same format and include similar information underneath each heading – Project Summary/Overview, Project Background (where and why the project started, project goals, cost and funding source, climate impacts of concern), Project Implementation (project process, resources and information used, stakeholder or outreach engagement), Project Outcomes and Conclusions (resources produced, anticipated and unanticipated outcomes, metrics for success, challenges and if/how they were overcome, next steps, lessons learned), and References (any resources used for or produced from the project). Case studies were written and went through an internal review before being sent to the project contact for review.

Report

The synthesis report was written using the information generated through the review of relevant literature, interviews and surveys, and selected case studies. The report presents a summary review of observed and projected impacts of climate change on freshwater resources in the Great Lakes, a summary of adaptation theory and practice, an analysis of the trends in regional adaptation activities, an overview of the challenges identified by the survey participants, and concludes with the identification of potential opportunities for the creation of new or enhancement of existing adaptation activities.

C. Adaptation Case Studies from the Great Lakes Region (by strategy)

Capacity Building

Design or reform institutions

- A Roadmap for Action: The Chicago Climate Action Plan
- Addressing Climate Change in the International Upper Great Lakes Study
- Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed
- Canada's Regional Adaptation Collaboratives Climate Change Program
- ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State
- Climate Adaptation in the City of Ann Arbor, Michigan
- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change Adaptation Planning at the State Level in Pennsylvania
- Climate Consortium for Research Action and Integration (CC-RAI)
- Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force
- Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States
- Developing Ontario's Climate Change Adaptation Strategy and Action Plan
- Fostering a Climate-Informed Community Perspective in the Great Lakes: The Great Lakes Community Climate Program
- Great Lakes Adaptation Assessment for Cities
- Great Lakes Restoration Initiative
- Helping Michigan's Farmers Understand and Adapt to the Impacts of Climate Change
- Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin
- Ontario Regional Adaptation Collaborative
- Planning for Climate Change in the Province of Quebec
- Preparing for Climate Change in the Great Lakes Region
- Quebec Regional Adaptation Collaborative
- The Chicago Wilderness Climate Action Plan for Nature
- The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region
- The Michigan Climate Coalition: Enhancing Networking and Collaboration, Communication and Action Around Climate Change in Michigan
- The National Oceanic and Atmospheric Administration's Great Lakes Climate Initiatives
- The Ontario Centre for Climate Impacts and Adaptation Resources' Climate Adaptation Initiatives
- U.S. Global Change Research Program
- Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies

Conduct research, studies, and assessments

- A Roadmap for Action: The Chicago Climate Action Plan
- Adapting to Climate Change in Ontario Parks
- Addressing Climate Change in the International Upper Great Lakes Study
- Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise and Lake Level Changes
- Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed
- Canada's Regional Adaptation Collaboratives Climate Change Program
- ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State
- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change Adaptation Planning at the State Level in Pennsylvania
- Climate Change and Coastal Adaptation Options for the Great Lakes
- Climate Change, the Great Lakes, and Mining
- Climate Consortium for Research Action and Integration (CC-RAI)
- Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force
- Developing a Climate Change Adaptation Plan for Forest and Water Resources in Alger County, Michigan
- Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States
- Developing Ontario's Climate Change Adaptation Strategy and Action Plan
- Fish, Fisheries, and Water Resources: Adapting to Ontario's Changing Climate
- Great Lakes Adaptation Assessment for Cities
- Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Adaptation Strategies
- Helping Michigan's Farmers Understand and Adapt to the Impacts of Climate Change
- Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA) Using GPS Telemetry
- Integrating Climate Change into Municipal Watershed Management in Ontario
- Integrating Climate Change into Water Quality Monitoring on the Fond du Lac Reservation in Minnesota
- Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds
- London, Ontario's Climate Change Adaptation Strategy
- Ontario Regional Adaptation Collaborative
- Pennsylvania Sea Grant's Climate Change Outreach and Research Projects
- Quebec City's Environmental Services Adaptation Plan
- Quebec Regional Adaptation Collaborative
- Rein in the Runoff: Michigan's Spring Lake Stormwater Management Project
- Sustaining Lakes in a Changing Environment (SLICE): A Long-term Monitoring and Evaluation Program

- The City of Toronto’s Climate Change Adaptation Strategy: From Development to Implementation
- The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region
- The National Oceanic and Atmospheric Administration’s Great Lakes Climate Initiatives
- The Ontario Centre for Climate Impacts and Adaptation Resources’ Climate Adaptation Initiatives
- U.S. Global Change Research Program
- Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio
- Water Supply Planning for Illinois
- Weather – Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study
- Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies

Conduct training and planning exercises

- Adapting to Climate Change in Ontario Parks
- Addressing Climate Change in the International Upper Great Lakes Study
- Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed
- ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State
- Climate Adaptation in the City of Ann Arbor, Michigan
- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change and Coastal Adaptation Options for the Great Lakes
- Climate Consortium for Research Action and Integration (CC-RAI)
- Developing a Climate Change Adaptation Plan for Forest and Water Resources in Alger County, Michigan
- Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States
- Developing Ontario’s Climate Change Adaptation Strategy and Action Plan
- Enhancing Climate Change Education and Outreach for Wisconsin’s Coastal Communities
- Fish, Fisheries, and Water Resources: Adapting to Ontario’s Changing Climate
- Fostering a Climate-Informed Community Perspective in the Great Lakes: The Great Lakes Community Climate Program
- Great Lakes Adaptation Assessment for Cities
- Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Adaptation Strategies
- Helping Michigan’s Farmers Understand and Adapt to the Impacts of Climate Change
- Pennsylvania Sea Grant’s Climate Change Outreach and Research Projects
- Preparing for Climate Change in the Great Lakes Region
- Quebec City’s Environmental Services Adaptation Plan

- The City of Toronto’s Climate Change Adaptation Strategy: From Development to Implementation
- The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region
- The Michigan Climate Coalition: Enhancing Networking and Collaboration, Communication and Action Around Climate Change in Michigan
- The National Oceanic and Atmospheric Administration’s Great Lakes Climate Initiatives
- The National Wildlife Federation’s Climate-Smart Restoration Partnership in the Great Lakes
- The Ontario Centre for Climate Impacts and Adaptation Resources’ Climate Adaptation Initiatives
- Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio
- Using Green Infrastructure to Prevent Sewage Overflows in Detroit
- Weather – Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study

Increase/improve public awareness, education, and outreach efforts

- Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed
- ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State
- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change and Coastal Adaptation Options for the Great Lakes
- Climate Change Mitigation and Adaptation Planning in Wisconsin’s Lake Michigan Coastal Communities
- Climate Change, the Great Lakes, and Mining
- Climate Consortium for Research Action and Integration (CC-RAI)
- Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force
- Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States
- Developing Ontario’s Climate Change Adaptation Strategy and Action Plan
- Enhancing Climate Change Education and Outreach for Wisconsin’s Coastal Communities
- Fish, Fisheries, and Water Resources: Adapting to Ontario’s Changing Climate
- Fostering a Climate-Informed Community Perspective in the Great Lakes: The Great Lakes Community Climate Program
- Great Lakes Adaptation Assessment for Cities
- Great Lakes Observing System
- Helping Michigan’s Farmers Understand and Adapt to the Impacts of Climate Change
- Integrating Climate Change into Municipal Watershed Management in Ontario
- Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin

- Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds
- New York’s Climate Smart Communities Program
- Pennsylvania Sea Grant’s Climate Change Outreach and Research Projects
- Preparing for Climate Change in the Great Lakes Region
- Rein in the Runoff: Michigan’s Spring Lake Stormwater Management Project
- The Chicago Wilderness Climate Action Plan for Nature
- The Michigan Climate Coalition: Enhancing Networking and Collaboration, Communication and Action Around Climate Change in Michigan
- The National Oceanic and Atmospheric Administration’s Great Lakes Climate Initiatives
- The National Wildlife Federation’s Climate-Smart Restoration Partnership in the Great Lakes
- The Ontario Centre for Climate Impacts and Adaptation Resources’ Climate Adaptation Initiatives
- U.S. Global Change Research Program
- Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio
- Using Green Infrastructure to Prevent Sewage Overflows in Detroit
- Water Supply Planning for Illinois
- Weather – Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study
- Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies

Create/enhance resources and tools

- Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise and Lake Level Changes
- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change Mitigation and Adaptation Planning in Wisconsin’s Lake Michigan Coastal Communities
- Climate Consortium for Research Action and Integration (CC-RAI)
- Developing Ontario’s Climate Change Adaptation Strategy and Action Plan
- Enhancing Climate Change Education and Outreach for Wisconsin’s Coastal Communities
- Great Lakes Adaptation Assessment for Cities
- Great Lakes Observing System
- Helping Michigan’s Farmers Understand and Adapt to the Impacts of Climate Change
- Integrating Climate Change into Municipal Watershed Management in Ontario
- Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin
- Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds
- New York’s Climate Smart Communities Program
- Rein in the Runoff: Michigan’s Spring Lake Stormwater Management Project

- The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region
- The National Oceanic and Atmospheric Administration’s Great Lakes Climate Initiatives
- The National Wildlife Federation’s Climate-Smart Restoration Partnership in the Great Lakes
- The Ontario Centre for Climate Impacts and Adaptation Resources’ Climate Adaptation Initiatives
- Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio
- Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies

Monitor climate change impacts and adaptation efficacy

- Addressing Climate Change in the International Upper Great Lakes Study
- Climate Change Adaptation Planning at the State Level in Minnesota
- Developing Ontario’s Climate Change Adaptation Strategy and Action Plan
- Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA) Using GPS Telemetry
- Integrating Climate Change into Water Quality Monitoring on the Fond du Lac Reservation in Minnesota
- Planning for Climate Change in the Province of Quebec
- Sustaining Lakes in a Changing Environment (SLICE): A Long-term Monitoring and Evaluation Program

Policy

Develop/implement adaptation plans

- A Roadmap for Action: The Chicago Climate Action Plan
- Adapting to Climate Change in Ontario Parks
- ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State
- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change Adaptation Planning at the State Level in Pennsylvania
- Developing a Climate Change Adaptation Plan for Forest and Water Resources in Alger County, Michigan
- Developing Ontario’s Climate Change Adaptation Strategy and Action Plan
- Great Lakes Adaptation Assessment for Cities
- London, Ontario’s Climate Change Adaptation Strategy
- New York’s Climate Smart Communities Program
- Planning for Climate Change in the Province of Quebec
- Quebec City’s Environmental Services Adaptation Plan
- The Chicago Wilderness Climate Action Plan for Nature
- The City of Toronto’s Climate Change Adaptation Strategy: From Development to Implementation

- The Ontario Centre for Climate Impacts and Adaptation Resources' Climate Adaptation Initiatives
- Weather – Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study
- Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies

Create new or enhance existing policies or regulations

- A Roadmap for Action: The Chicago Climate Action Plan
- Addressing Climate Change Impacts in the Great Lakes Water Quality Agreement
- Addressing Climate Change in the International Upper Great Lakes Study
- Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed
- Climate Adaptation in the City of Ann Arbor, Michigan
- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change Adaptation Planning at the State Level in Pennsylvania
- Climate Change, the Great Lakes, and Mining
- Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force
- Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States
- Developing Ontario's Climate Change Adaptation Strategy and Action Plan
- Incorporating Climate Change into TMDL Decisions for Lake Champlain
- Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin
- Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds
- Planning for Climate Change in the Province of Quebec
- Project Clean Lake: Updating Cleveland's Sewer Systems to Reduce Stormwater Overflows
- The Chicago Wilderness Climate Action Plan for Nature

Develop/implement adaptive management strategies

- Addressing Climate Change in the International Upper Great Lakes Study
- Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin
- Sustaining Lakes in a Changing Environment (SLICE): A Long-term Monitoring and Evaluation Program

Natural Resource Management and Conservation

Incorporate climate-smart guidelines into restoration

- Great Lakes Restoration Initiative
- The National Wildlife Federation's Climate-Smart Restoration Partnership in the Great Lakes

Enhance connectivity and areas under protection

- A Roadmap for Action: The Chicago Climate Action Plan
- Adapting to Climate Change in Ontario Parks
- Climate Change Adaptation Planning at the State Level in Minnesota
- Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Adaptation Strategies
- Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA) Using GPS Telemetry
- The Chicago Wilderness Climate Action Plan for Nature

Reduce local climate or related change

- A Roadmap for Action: The Chicago Climate Action Plan
- Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed
- Great Lakes Restoration Initiative
- The Chicago Wilderness Climate Action Plan for Nature

Reduce non-climate stressors likely to interact with climate change

- Addressing Climate Change Impacts in the Great Lakes Water Quality Agreement
- Great Lakes Restoration Initiative
- Pennsylvania Sea Grant's Climate Change Outreach and Research Projects
- Project Clean Lake: Updating Cleveland's Sewer Systems to Reduce Stormwater Overflows
- Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio

Infrastructure, Planning, and Development

Make infrastructure resistant or resilient to climate change

- A Roadmap for Action: The Chicago Climate Action Plan
- Fish, Fisheries, and Water Resources: Adapting to Ontario's Changing Climate
- Integrating Climate Change into Municipal Watershed Management in Ontario
- Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin
- Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds
- London, Ontario's Climate Change Adaptation Strategy
- Project Clean Lake: Updating Cleveland's Sewer Systems to Reduce Stormwater Overflows
- Rein in the Runoff: Michigan's Spring Lake Stormwater Management Project
- Water Supply Planning for Illinois
- Weather – Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study

Community planning (developing climate-smart communities)

- Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed
- Climate Adaptation in the City of Ann Arbor, Michigan
- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change Mitigation and Adaptation Planning in Wisconsin’s Lake Michigan Coastal Communities
- Great Lakes Adaptation Assessment for Cities
- New York’s Climate Smart Communities Program
- Project Clean Lake: Updating Cleveland’s Sewer Systems to Reduce Stormwater Overflows
- Rein in the Runoff: Michigan’s Spring Lake Stormwater Management Project
- The Ontario Centre for Climate Impacts and Adaptation Resources’ Climate Adaptation Initiatives
- Using Green Infrastructure to Prevent Sewage Overflows in Detroit

Create or modify shoreline management measures

- A Roadmap for Action: The Chicago Climate Action Plan
- Climate Adaptation in the City of Ann Arbor, Michigan
- Integrating Climate Change into Water Quality Monitoring on the Fond du Lac Reservation in Minnesota
- Project Clean Lake: Updating Cleveland’s Sewer Systems to Reduce Stormwater Overflows
- The Chicago Wilderness Climate Action Plan for Nature
- Using Green Infrastructure to Prevent Sewage Overflows in Detroit

Develop disaster preparedness plans and policies

- Climate Change Adaptation Planning at the State Level in Minnesota
- Climate Change Mitigation and Adaptation Planning in Wisconsin’s Lake Michigan Coastal Communities

D. Adaptation Case Studies Compendium²⁵⁴

The case studies in this compendium are presented in alphabetical order beginning on page 79; the following list displays the case study titles by geographic location:

Great Lakes Region

Addressing Climate Change Impacts in the Great Lakes Water Quality Agreement
 Addressing Climate Change in the International Upper Great Lakes Study
 Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise and Lake Level Changes
 Climate Change and Coastal Adaptation Options for the Great Lakes
 Fostering a Climate-Informed Community Perspective in the Great Lakes: The Great Lakes Community Climate Program
 Great Lakes Adaptation Assessment for Cities
 Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Adaptation Strategies
 Great Lakes Observing System
 Great Lakes Restoration Initiative
 Preparing for Climate Change in the Great Lakes Region
 The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region
 The National Oceanic and Atmospheric Administration’s Great Lakes Climate Initiatives
 The National Wildlife Federation’s Climate-Smart Restoration Partnership in the Great Lakes

United States

Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force
 Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States
 U.S. Global Change Research Program

Illinois

A Roadmap for Action: The Chicago Climate Action Plan
 The Chicago Wilderness Climate Action Plan for Nature
 Water Supply Planning for Illinois

Michigan

Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed
 Climate Adaptation in the City of Ann Arbor, Michigan
 Climate Change, the Great Lakes, and Mining
 Developing a Climate Change Adaptation Plan for Forest and Water Resources in Alger County, Michigan
 Helping Michigan’s Farmers Understand and Adapt to the Impacts of Climate Change
 Rein in the Runoff: Michigan’s Spring Lake Stormwater Management Project
 The Michigan Climate Coalition: Enhancing Networking and Collaboration, Communication, and Action Around Climate Change in Michigan

²⁵⁴ These case studies will also be available on the Climate Adaptation Knowledge Exchange (CAKE; www.cakex.org)

Using Green Infrastructure to Prevent Sewage Overflows in Detroit

Minnesota

Climate Change Adaptation Planning at the State Level in Minnesota

Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA) using GPS Telemetry

Integrating Climate Change into Water Quality Monitoring on the Fond du Lac Reservation in Minnesota

Sustaining Lakes in a Changing Environment (SLICE): A Long-term Monitoring and Evaluation Program

Weather – Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study

New York

ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State Incorporating Climate Change into TMDL Decisions for Lake Champlain

New York's Climate Smart Communities Program

Ohio

Project Clean Lake: Updating Cleveland's Sewer Systems to Reduce Stormwater Overflows

Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio

Pennsylvania

Climate Change Adaptation Planning at the State Level in Pennsylvania

Pennsylvania Sea Grant's Climate Change Outreach and Research Projects

Wisconsin

Climate Change Mitigation and Adaptation Planning in Wisconsin's Lake Michigan Coastal Communities

Enhancing Climate Change Education and Outreach for Wisconsin's Coastal Communities

Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin

Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds

Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies

Canada

Canada's Regional Adaptation Collaboratives Climate Change Program

Ontario

Adapting to Climate Change in Ontario Parks

Climate Consortium for Research Action and Integration (CC-RAI)

Developing Ontario's Climate Change Adaptation Strategy and Action Plan

Fish, Fisheries, and Water Resources: Adapting to Ontario's Changing Climate

Integrating Climate Change into Municipal Watershed Management in Ontario

London, Ontario's Climate Change Adaptation Strategy

Ontario Regional Adaptation Collaborative

The City of Toronto's Climate Change Adaptation Strategy: From Development to Implementation
The Ontario Centre for Climate Impacts and Adaptation Resources' Climate Adaptation Initiatives

Quebec

Planning for Climate Change in the Province of Quebec
Quebec City's Environmental Services Adaptation Plan
Quebec Regional Adaptation Collaborative

A Roadmap for Action: The Chicago Climate Action Plan

By: Rachel M. Gregg and Jessica L. Hitt

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Project Summary/Overview

In 2006, former Chicago Mayor Richard M. Daley established a Climate Change Task Force (Task Force) that was charged with evaluating the potential impacts of climate change and developing an action plan for the city. After conducting impacts, economic costs, and risk assessments, the city released the Chicago Climate Action Plan (CCAP) in late 2008. The plan functions much like a roadmap for climate action with five overarching strategies, including nine adaptation actions. Implemented adaptation actions thus far include integration of future climate scenarios into stormwater management as well as the development of green urban design projects to reduce heat and flooding.

Project Background

The City of Chicago, located on the shores of Lake Michigan, is the third largest city in the United States. It is located within the Chicago Portage, which connects the watersheds of the Mississippi River and the Great Lakes. Major freshwater bodies in the area include Lake Michigan and the Chicago and Calumet rivers. The city's climate is already experiencing change, including several degrees of warming since 1980. Impacts of concern include increases in both annual and extreme temperatures, changing precipitation patterns, changing lake levels, and decreasing ice cover, along with a host of other climate impacts. Increasing temperatures will result in more frequent heat waves, more 100° days, and serious repercussions for public health. More frequent and extreme precipitation events will result in flooding and could overwhelm the city's sewage systems, causing the pipes to back up with raw sewage.

The City of Chicago's climate change efforts began in 2006 when then Mayor Daley established a multi-stakeholder Task Force to develop plans to reduce the city's greenhouse gas emissions and help the city adapt to both existing and projected climate impacts. The Task Force commissioned in-depth impacts and vulnerability assessments and an economic analysis of projected impacts and costs of inaction. The CCAP effort has been funded by a coalition of diverse partners and has drawn financial support from a host of sources ranging from federal stimulus funds to private foundation support, state funds, and *pro bono* and in-kind support. Since 2008, the CCAP has received or leveraged over \$142 million in funds.

Project Implementation

Research and Analysis

The City of Chicago's climate change planning efforts were characterized by robust assessments of impacts, economic costs, and risks. Chicago was interested from the beginning in a joint mitigation

and adaptation planning effort and wanted to base decisions on sound science. The impacts assessment (*Climate Change and Chicago: Projections and Potential Impacts*), spearheaded by researchers from the University of Illinois at Urbana-Champaign and Texas Tech University, examined impacts under two futures – a high emissions scenario of 1000 ppm CO₂ by 2100 and a low emissions scenario of 550 ppm CO₂ by 2100 (Hayhoe and Wuebbles 2007). The high scenario represented business-as-usual practices and the low scenario represented a future in which major reductions in greenhouse gases were made over the coming years. The analysis included scientific and statistical downscaling of three climate models and consideration of historical observations. The assessment found that Chicago was already experiencing effects from climate change and noted that projected impacts, including changes in temperature and precipitation, will have serious ramifications for the city, its infrastructure and services, and the health and safety of residents.

The second phase of analysis was conducted by the risk management firm Oliver Wyman; staff used the initial assessment results to conduct an economic risk analysis of projected impacts to city departments' infrastructure and services under the two emissions scenarios from 2010-2100. The analysis looked at both the costs of inaction and the benefits of adaptation action. The findings indicated that the total cost of climate-induced impacts on city departments could range from \$690 million under the low emissions scenario to \$2.54 billion under the high emissions scenario; the analysis concluded that the city should pursue mitigation and adaptation efforts in order to maximize the reduction in potential economic costs for the city (Oliver Wyman 2008).

The third phase involved a risk prioritization of the findings of the impacts assessment and economic analysis based on likelihood and consequences of occurrence by MWH Global, an engineering firm. Focusing on four primary impacts – extreme heat events, intense precipitation, infrastructure damage, and habitat degradation – MWH developed and ranked proposed adaptation actions; these actions were ranked according to benefits, costs, time, and projected barriers to implementation, and MWH provided recommended actions based on these rankings (MWH 2008).

Planning

The CCAP was released in 2008 and outlines five strategies and 35 actions for Chicago to reduce its emissions and adapt to climate change. The five overarching strategies include: (1) Energy Efficient Buildings, (2) Clean and Renewable Energy Sources, (3) Improved Transportation Options, (4) Reduced Waste and Industrial Pollution, and (5) Adaptation. Of the 35 actions, nine apply to adaptation; these include: (1) Manage Heat, (2) Pursue Innovative Cooling, (3) Protect Air Quality, (4) Manage Stormwater, (5) Implement Green Urban Design, (6) Preserve Our Plants and Trees, (7) Engage the Public, (8) Engage Businesses, and (9) Plan for the Future.

Project Outcomes and Conclusions

Since the release of the CCAP, considerable progress has been made across the city in both the reduction of greenhouse gases and implementation of adaptation measures. The city created an Adaptation Advisory Group to provide high-level aid and guidance for the city's adaptation efforts, including implementation, monitoring success, and communications. The city's Natural Environment Adaptation Working Group is also prioritizing the protection and enhancement of connectivity and corridors. The group created a guiding document, which includes the following strategies specific to enhancing connectivity: (1) expanding the Green Infrastructure Vision map in order to identify and prioritize key areas of connectivity, (2) protecting buffers and open space, (3) improving existing habitat on publicly-owned properties (e.g., parks, preserves) that act or may act as

critical corridors, (4) promoting potential expansion onto private lands (e.g., golf courses, residential yards), and (5) restoring wetlands and other habitats that maximize connectivity.

The city developed evaluation metrics and plans to measure success through regular progress reports. Much of the progress to date on the adaptation strategy has been focused on stormwater management and green urban design. There have been increased efforts to establish permeable surface areas, green roofs, and urban tree canopies across the city. The [Chicago Trees Initiative](#) aims to mitigate the effects of increasing temperatures and stormwater management problems by increasing canopy cover in the city. Planting lists were updated to include the foliage and trees that will be more likely to survive in a warmer climate; for example, white oak, the state tree of Illinois, is no longer on the city's [approved urban planting list](#). Instead, tree species from the south, such as swamp oaks, which are acclimated to warmer climates, have been added to the list. In addition, the [Green Urban Design plan](#) has prioritized efforts to increase permeable surfaces around the city through the [Green Alley Program](#). This program has both adaptation (reduced stormwater runoff, temperature regulation) and mitigation (increased energy efficiency, reduced energy costs) benefits.

The cutting-edge CCAP planning process produced a number of resources, tools, and products that may help other urban areas looking to prepare for climate change. The city also released a '[lessons learned](#)' document from the planning process that includes a checklist and analysis of best practices (Parzen 2009). One example is the utility of the impacts, economic, and risk assessments; these activities proved vital to the success of the planning process, providing Task Force members with a common basis from which to make informed decisions. The results of the assessments were also useful for communicating with the public. The documents produced in these processes may serve as useful tools for other cities looking to prioritize climate action and communicate with multiple stakeholders.

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Status

Information gathered from publications and other resources. Reviewed by project contact.

Citation

Gregg, R. M. & Hitt, J. L. (2012). *A Roadmap for Action: The Chicago Climate Action Plan* [Case study on a project of the City of Chicago]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments

Policy: Develop/implement adaptation plans, Create new or enhance existing policies or regulations

Natural Resource Management and Conservation: Enhance connectivity and areas under protection,

Reduce local climate or related change Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change; Create or modify shoreline management measures

Adapting to Climate Change in Ontario Parks

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Project Summary/Overview

Climate change is expected to negatively impact the parks and protected lands in Ontario. To better prepare for these adverse impacts, 45 experts were convened and surveyed in order to identify the most feasible and desirable adaptation recommendations in a systematic fashion. In sum, over 1,000 recommendations were generated and later condensed down to nearly 160. Fifty-six of these recommendations were deemed “desirable” or “highly desirable” by panel experts but only two were considered to be highly feasible. This case study reviews the survey process and results developed to help Ontario Parks adapt to climate change.

Project Background

It is generally well accepted that climate change will present unforeseen challenges and difficulties to protected areas across Canada. Canada has over 101.2 million hectares reserved as protected areas, roughly 9.92% of Canada’s total land area. In a survey of 35 protected areas conducted by the Canadian Council on Ecological Areas, 89% of managers thought that climate change was a relevant issue necessitating management considerations and 91% felt that climate change will substantially alter protected areas policy and planning over the next 25 years; no one surveyed had yet incorporated climate change adaptation policies into their management strategies. Indeed, 86% of those surveyed felt that they did not have the capacity to properly deal with climate change issues (Lemieux et al. 2011).

Instrumental records indicate that Ontario has, in general, experienced a warming trend since the Industrial Revolution. While the average global temperature has warmed by about 0.74°C over the past century, parts of Ontario have experienced double that warming trend over the same time period. These warming trends are projected to increase into the future due to the increasing amounts of greenhouse gases being emitted in to the atmosphere. For example, the Pacific Climate Impacts Consortium used 32 global climate models to project an increase in mean temperature of 3.1-10.6°C by the 2080s over terrestrial Canada and a +2.5 to +19.2% change in mean annual precipitation.

Ontario has over 621 protected areas – 329 provincial parks and 292 conservation reserves. Given the diverse landscapes housed within Ontario’s protected areas, the impacts of climate change will be place-specific and varied but may include: changes in biodiversity and species’ ranges based upon thermal tolerances; novel and invasive species in new geographic locales; altered recreational and tourism opportunities; and changing fire regimes and patterns.

Project Implementation

In order to develop viable climate change adaptation strategies for protected areas in Ontario, a team led by the University of Waterloo, Ontario Parks, and the Parks Research Forum of Ontario

(now the Centre for Applied Science in Ontario Protected Areas) was formed in 2004. Their research objectives were to:

1. Evaluate the desirability of climate change adaptation options;
2. Evaluate the feasibility of climate change adaptation options; and
3. Prioritize climate change adaptation options for Ontario Parks.

The team used a seven-step iterative adaptation methodology to guide their study. The key steps were to:

1. Engage stakeholders through workshops;
2. Define the problems managers encountered when trying to assess sensitivities to climate change (see Lemieux and Scott 2005);
3. Assess adaptive capacities of regions or organizations;
4. Identify adaptation options including current and potential future policies;
5. Evaluate adaptation options and select action items based upon desirability, feasibility, and implementation timeframe;
6. Implement selected adaptation items; and
7. Monitor and evaluate adaptation efficacy.

This process was presented to 45 expert panelists who collectively produced 1,130 climate change adaptation options. These strategies were then synthesized into 164 recommendations and further evaluated based upon their desirability, feasibility, and implementation timeframe. Lemieux et al. (2007) detail the ranking system and outcomes in their report; some highlights include:

- Policy, system planning, and legislation:
 - Protected areas system planning should identify “representative” organisms/landscapes to protect in order to increase the likelihood that associated plants/animals/habitats will remain protected under climate change.
 - The focus should shift from ecological “patterns” and more to ecological “processes.”
 - Parks should adopt and employ a science-based adaptive management approach.
 - The concept of ecological integrity, a long-term mandate for Ontario parks, should be defined to include “acceptable rates of change” with climate change considerations.
- Management direction:
 - Climate change should be integrated into parks’ management plans and statements.
 - The role and value of protected areas and their associated “zones” needs to be reevaluated every ten years to better assess the impacts of a changing climate.
 - Species-at-risk translocation and active management may be undesirable activities.
- Operations and development:
 - Parks should strive to reduce their greenhouse gas emissions and identify alternative sources of energy and waste reduction strategies.
- Research, monitoring, and reporting:
 - A monitoring program specific to climate change should be established to assess the impacts and trends of climate-related changes, especially in regards to regionally-threatened species and other ‘target’ species.
 - A volunteer-based monitoring system could reduce the costs and labor requirements of an effective monitoring system, but participants need to be properly trained and educated to validate observations.

- Corporate culture and function:
 - Internal capacity should be built within the park’s system through internal training sessions and science workshops to foster an informed and climate aware staff.
- Education, interpretation, and outreach:
 - Ontario Parks should develop interpretation and outreach materials and activities to inform the public about climate change impacts to regional parks.
 - A national climate change working group should be established to address climate change and protected area issues.

To further refine and focus adaptation strategies, a ‘first-order’ list was developed based upon those recommendations that had been considered to be desirable or very desirable by 90% or more of the panel; this limited the number of recommendations to 56. Of the 56 highly desirable recommendations, half were evaluated as “definitely not feasible” to “probably not feasible” by the panel. Only two recommendations were listed as “definitely implementable”:

1. Ontario Parks could develop a strategic and corporate policy on climate change and protected areas to provide sufficient direction for planning and management; and
2. Future protected natural areas establishment could be focused on protecting the northern limits of species’ ranges and other highly vulnerable species.

This survey was partially funded by the Government of Canada’s Climate Change Impacts and Adaptation Program (CCIAP) (Project #A1393), the Ontario Ministry of Natural Resources (MNR), and the Social Sciences and Humanities Research Council.

Project Outcomes and Conclusions

The OMNR is actively pursuing ways to prepare for and adapt to the impacts of climate change. Comprehensive reports and practitioner surveys are valuable tools to begin the process of climate change adaptation. Unfortunately, many of the recommendations developed through the survey process are currently unattainable according to a majority of experts; however, efforts are being made to help resource and park managers to feel more empowered and prepared to adapt to a changing climate.

In 2007, the report *Climate Change and Ontario’s Provincial Parks: Towards and Adaptation Strategy* was released (Lemieux et al. 2007). It serves as a program-level strategy and action plan to implement a framework to help the OMNR prepare for the impacts of climate change. The framework is divided in to three themes: understanding climate change, mitigating the impacts of climate change, and adapting to climate change. Each theme has strategies and sub-strategies to support and better prepare Ontarians for adverse climate change impacts.

References

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<http://www.georgewright.org/282lemieux.pdf>

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *Adapting to Climate Change in Ontario Parks* [Case study on a project of the Ontario Ministry of Natural Resources]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Conduct training and planning exercises

Policy: Develop/implement adaptation plans

Natural Resource Management and Conservation: Enhance connectivity and areas under protection

Addressing Climate Change Impacts in the Great Lakes Water Quality Agreement

By: Rachel M. Gregg

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Project Summary/Overview

The Great Lakes Water Quality Agreement (Agreement), initially signed in 1972, is a binational accord between the United States and Canada to protect regional water quality in the Great Lakes basin. An amendment to the Agreement was released in September 2012; among the additions is an annex dedicated to climate change.

Project Background

The Great Lakes and their associated tributaries are major drinking water sources and are important to the region's ecosystems, commercial sectors, and recreational activities. Primary threats to water quality in the Great Lakes include toxins, pollutant loading, and harmful algae, all of which may be exacerbated by the onset of climate change and have negative impacts on human and ecosystem health. For example, changes in temperature may affect the toxicity of certain chemicals and/or interact with nutrient pollution to enhance algal blooms.

The Agreement has guided transboundary efforts to protect water quality in the Great Lakes region since 1972, building upon and reaffirming the binational cooperation outlined in the [Boundary Waters Treaty of 1909](#). The Agreement has been amended in the past as new and pressing issues have emerged; the previous amendment was signed in 1987. A new amendment process began in 2009 to address urgent and emerging issues, including aquatic invasive species, habitat degradation, and climate change, among others.

Project Implementation

The Agreement, signed in September 2012 by U.S. Environmental Protection Agency Administrator Lisa P. Jackson and Canadian Environment Minister Peter Kent, commits the United States and Canada to “restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes basin” (Great Lakes Water Quality Protocol of 2012). It calls for the United States and Canada to cooperate on a variety of water quality issues in order to limit or eliminate environmental threats. Climate change impacts are included along with other issues in annexes of the Agreement. These sections include:

- Annex 1 – Areas of Concern
- Annex 2 – Lakewide Management
- Annex 3 – Chemicals of Mutual Concern
- Annex 4 – Nutrients

- Annex 5 – Discharges from Vessels
- Annex 6 – Aquatic Invasive Species
- Annex 7 – Habitat and Species
- Annex 8 – Groundwater
- Annex 9 – Climate Change Impacts
- Annex 10 – Science

The purpose of Annex 9 is to outline objectives “to identify, quantify, understand, and predict the climate change impacts on the quality of the Waters of the Great Lakes, and [to share] information that Great Lakes resource managers need to proactively address these impacts” (Great Lakes Water Quality Protocol of 2012). This section recognizes climate change impacts on water quality and the need to have broad cooperation between and among all levels of government in both countries with respect to climate science and actions to build adaptive capacity. The Annex recognizes the need for the Parties to consider climate change impacts when implementing the entire Agreement. In addition, the Annex determines that the countries need to: (1) develop and/or improve regional climate models, (2) improve the links between climate models and other regionally-relevant chemical/physical/biological models in order to assess impacts on ecosystem and human health as accurately as possible, (3) improve monitoring of impacts, (4) develop and enhance analytical tools to assess risk and vulnerability, and (5) coordinate binational monitoring, modeling, and analysis of climate change impacts.

Project Outcomes and Conclusions

The Agreement is a model of a binational, ecosystem-based approach to the management of water quality. Emerging issues of concern, including aquatic invasive species, nutrient and chemical pollution, habitat and species loss, and climate change, were integrated into a new version of the accord in 2012. The Amendment outlines a number of activities that will allow for the United States and Canada to be held accountable for progress made on improving the water quality of the Great Lakes. These measures include:

- Creating a Great Lakes Executive Committee to oversee the Agreement’s implementation. Each country will act as a co-chair and also have representation from other federal, state and provincial, tribal, and local government entities. This committee will meet at least twice per year and create Annex-specific sub-committees;
- Requiring triennial progress reports on all facets of the accord, including activities specifically identified in the annexes;
- Convening a Great Lakes Public Forum to meet every three years to allow for public stakeholder engagement on progress made on the Agreement’s outlined objectives and to inform future priorities and activities;
- Encouraging open access and exchange of any relevant data or information pertaining to water quality between the two countries; and
- Establishing the International Joint Commission as an independent science advisor to both countries.

References

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www.epa.gov/glnpo/glwqa/20120907-Canada-USA_GLWQA_FINAL.pdf

Status

Information gathered from interview with project contact June 25, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Addressing Climate Change Impacts in the Great Lakes Water Quality Agreement* [Case study on a project of the U.S. Environmental Protection Agency and the Canadian Ministry of the Environment]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Policy: Create new or enhance existing policies or regulations

Natural Resource Management and Conservation: Reduce non-climate stressors likely to interact with climate change

Addressing Climate Change in the International Upper Great Lakes Study

By: Rachel M. Gregg

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Project Summary/Overview

The International Upper Great Lakes Study (IUGLS) is a project of the International Joint Commission (IJC). The IUGLS was established to identify and evaluate potential improvements to outflow regulation of Lake Superior to better address changing interests and climate, and resulting impacts on water flows, water levels, and associated resources in the Great Lakes region.

Project Background

The IJC is responsible for managing the cooperative use and protection of the lakes and rivers that span the U.S.-Canadian border under the 1909 Boundary Waters Treaty. The IJC created the International Upper Great Lakes Study Board (Study Board) to improve research and information exchange that could enhance decision making regarding the regulation of regional water levels and flows. The Study Board provides recommendations to the IJC and the IJC is in turn responsible for making decisions on regulations and advising the Canadian and U.S. governments on management strategies.

The IUGLS, which is funded equally by the U.S. and Canadian governments, was created in order to evaluate potential improvements to outflow regulation of Lake Superior and identify possible effects on water flows, water levels, and associated resources in the region. The IUGLS identified the possible impacts of climate change on Great Lakes water levels, including increased temperatures, changes in frequency and intensity of weather events, and altered precipitation patterns that will likely cause a decrease in water supply to the region, in its 2005 report, [*Upper Lakes Plan of Study for the Review of the Regulation of Outflows from Lake Superior*](#).

Project Implementation

The Study Board hosted a workshop in June 2009 to discuss how adaptive management could be applied to the IUGLS. One recommendation from participants was the creation of an adaptive management strategy and a committee that could identify and organize climate change adaptation efforts relevant to the study's directive. In October 2009, the Study Board requested that the IJC expand the IUGLS scope to include the assessment of climate change impacts on water levels and identification of possible adaptation measures; on April 5, 2010, the governments of the United States and Canada agreed that the IUGLS could expand its scope and also consider structural and non-structural options to regulate water levels in a changing climate.

Project Outcomes and Conclusions

Barriers to evaluating projected climate change impacts in the IUGLS include limited availability of climate and other ecosystem data and inherent uncertainty. Advancing adaptive management through the IUGLS requires enhanced monitoring and modeling of precipitation and runoff, improved monitoring of human alterations to the lakes and connecting waterways, and increased dissemination of up-to-date information to planners and managers so that they can plan for changing water levels. These recommendations are made by the Study Board to the IJC in the report [*Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water Levels*](#).

The uncertainty about climate-induced lake level changes in the Great Lakes motivated the Study Board to create an Adaptive Management Working Group to assess vulnerabilities to extreme water levels, identify and address uncertainty, encourage flexible decision making, and seek support for a post-study, long-term monitoring program. The Working Group, chaired by Environment Canada and the Great Lakes Observing System, is developing a two-pronged strategy that will (1) allow for regulation changes as conditions change, and (2) provide information on climate change and water levels to related stakeholders and interest groups so that they may adapt their own practices.

References

IUGLS Overview:

http://pub.iugls.org/en/Facts%20Sheets/IUGLS%20Fact%20Sheet%201_web.pdf

IUGLS Lake Level Fluctuations: Causes and Implications

http://pub.iugls.org/en/Facts%20Sheets/IUGLS%20Fact%20Sheet%204_web.pdf

IUGLS. 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water Levels. Final Report to the International Joint Commission.

http://iugls.org/docs/Lake_Superior_Regulation_Full_Report.pdf

Kidd, J. 2009. Adaptive Management Workshop Report.

www.iugls.org/docs/DocStore/ProjectArchive/AMG_AdaptiveManagement/AMG09_LegerRead_AMStrategy/Reports/AMG09-R2_Kidd_WindsorAMWorkshop.pdf

Upper Lakes Plan of Study Revision Team. 2005. Upper Lakes Plan of Study for the Review of the Regulation of Outflows from Lake Superior. Prepared for the International Joint Commission.

<http://pub.iugls.org/en/rel/upper/FullReport.pdf>

Status

Information gathered from project contact's survey responses from June 21, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Addressing Climate Change in the International Upper Great Lakes Study* [Case study on a project of the International Joint Commission]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Monitor climate change impacts and adaptation efficacy
Policy: Create new or enhance existing policies or regulations, Develop/implement adaptive management strategies

*Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise and Lake Level Changes*²⁵⁵

By: Rachel M. Gregg

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Project Summary / Overview

The National Park Service (NPS) manages about 7,500 miles of shoreline in its various units throughout the United States. Since 2001, the NPS Geologic Resources Division has partnered with the U.S. Geological Survey (USGS) to conduct sea level rise and lake level change hazard assessments for 23 coastal NPS sites.

Project Background

The NPS manages 392 national parks and 40 national heritage sites over 84 million acres throughout the states and territories of the United States. Of these, the NPS manages about 7,500 miles of shoreline. Sea level rise associated with global climate change will likely result in increased coastal erosion, salinization of water supplies, flooding, and wetland inundation in coastal areas. Lake level changes in the Great Lakes region will likely occur because of changes in precipitation patterns and extremes. The NPS Geologic Resources Division and the USGS have been conducting sea level rise and lake level change hazard assessments for NPS units since 2001.

Project Implementation

The project involves creating maps of vulnerable areas through a coastal vulnerability index (CVI) to assist the NPS manage its protected areas in the face of rising sea levels. The CVI allows scientists to quantify potential physical changes to the shoreline from sea level rise. The criteria used in the assessment include six different variables that affect coastal vulnerability such as: **tidal range** and **wave height**, which contribute to inundation risk; **coastal slope**, which contributes to the susceptibility of the shoreline to flooding and rate of shoreline retreat or advance; **historic shoreline change**, which indicates erosion/accretion rates over time; **geomorphology**, which indicates relative erodability; and **historical sea level rise rates**, which indicate the correlation between eustatic sea level rise and tectonic uplift or subsidence. The CVI examines vulnerability in relation to the coast's natural adaptive ability to adjust to sea level rise in order to find a relative measure of the shoreline's natural vulnerability to sea level rise.

The project includes assessments of the following National Park units:

²⁵⁵ Also available at <http://www.cakex.org/case-studies/2815>

- Glacier Bay National Park and Preserve (Alaska)
- Kenai Fjords National Park (Alaska)
- Assateague Island National Seashore (Maryland/Virginia)
- Cape Cod National Seashore (Massachusetts)
- Cape Hatteras National Seashore (North Carolina)
- Cumberland Island National Seashore (Georgia)
- Fire Island National Seashore (New York)
- Gateway National Recreation Area (New York/New Jersey)
- Apostle Islands National Lakeshore (Wisconsin)
- Indiana Dunes National Lakeshore (Indiana)
- Sleeping Bear Dunes National Lakeshore (Michigan)
- Dry Tortugas National Park (Florida)
- Gulf Islands National Seashore (Florida/Mississippi)
- Padre Island National Seashore (Texas)
- Virgin Islands National Park (Virgin Islands)
- Channel Islands National Park (California)
- Golden Gate National Recreation Area (California)
- Olympic National Park (Washington)
- Point Reyes National Park (California)
- Kaloko-Honokōhau National Historical Park (Hawaii)
- National Park of American Samoa (American Samoa)
- War in the Pacific National Historical Park (Guam)

Project Outcomes and Conclusions

CVI assessments for each park are available [here](#). These assessments are being used to inform long-term management decisions and to assess long-term threats to natural and cultural resources in NPS coastal units.

References

- Thieler, E. R. & Williams, S. J. (2002). Vulnerability of U.S. national parks to sea-level rise and coastal change (USGS Fact Sheet FS-095-02). Woods Hole, MA: U.S. Geological Survey.
<http://pubs.usgs.gov/fs/fs095-02/fs095-02.pdf>
- USGS Relative Coastal Vulnerability Assessment of National Park Units to Sea-Level Rise
<http://woodshole.er.usgs.gov/project-pages/nps-cvi/>

Status

Information gathered from publications and other resources.

Citation

Gregg, R. M. (2010). *Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise and Lake Level Changes* [Case study on a project of the National Park Service - Geologic Resources Division and the U.S. Geological Survey - Woods Hole]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Create/enhance resources and tools

Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed

By: Rachel M. Gregg

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Project Summary/Overview

The Huron River Watershed Council (HRWC) is a nonprofit based in Ann Arbor, Michigan that works to protect and sustain the natural resources and human communities in the Huron River watershed. The HRWC engages in a number of activities in watershed science, management, education, and stewardship, and has recently incorporated climate change as an important stressor on its planning and activities. In addition to improving the resilience of the watershed through programmatic work, the HRWC has also initiated two projects to support climate change adaptation and mitigation efforts: Making Climate-Resilient Communities and Saving Water Saves Energy.

Project Background

Climate impacts of concern to the watershed include increased flooding and droughts as well as associated second order changes such as decreased water quality and quantity. These issues are especially important as the watershed already experiences major stressors to water quality and natural hydrology because of phosphorus loading and a high percentage of dams and impervious surfaces in the region.

The HRWC has recognized climate change as an overarching threat to the organization's goal to protect the watershed in recent years. The [2009 Climate Change Edition](#) of the quarterly Huron River Report was created to make sure that climate change was stressed as an important issue that affects natural resources, human communities, and the ability of the HRWC to achieve its mission. The report addressed the impacts of climate change on the Huron River watershed as well as the number of HRWC activities that already incorporate some level of mitigation and adaptation effort to increase watershed resilience, such as stream monitoring, wetlands protection, stormwater and watershed planning, natural areas mapping, public information and education, and advocacy efforts. For example, the HRWC's Stream Buffer Initiative encourages local residents to plant buffers on streamside/lakeside property to reduce the effects of increased water flows. The HRWC created a model buffer ordinance with support from the Environmental Protection Agency and the Michigan Department of Environmental Quality, which has been adopted by the towns of Scio and Green Oak; the ordinance provides recommendations on permitted uses and activities within buffer zones (e.g., flood control structures, water quality monitoring), buffer width and zoning, and maintenance requirements.

Two HRWC projects are specifically addressing the climate issue. The Making Climate-Resilient Communities project was funded with a total of \$80,000 by contributions from the Mott

Foundation, Friedman Family Foundation, City of Ann Arbor, Porter Family Foundation, Esperance Family Foundation, Upton Foundation, Washtenaw County Water Resources Commissioner, and the Great Lakes Integrated Sciences and Assessments Center (GLISA). This project aims to create climate-smart communities that can develop and implement adaptation strategies to improve their resilience to climate change. The Saving Water Saves Energy project also started in fall 2011 and was developed in partnership with the Masco Corporate Foundation. This three-year project is aimed at reducing water usage as a dual mitigation and adaptation strategy to reduce greenhouse gas emissions and improve water conservation.

Project Implementation

Making Climate-Resilient Communities

Working with the GLISA and River Network over the course of one year (2011-2012), the HRWC has convened multiple workshops to allow participants to examine how climate change is affecting communities and develop strategies to help these communities respond to and prepare for climate change. The project and participants have been divided into three sector groups – water infrastructure (water and stormwater utilities, wastewater treatment facilities), in-stream flows (dam operation, biology, hydrology), and natural infrastructure (land preservation, wetland restoration, floodplain management). After an initial kickoff meeting in December 2011 attended by 30 stakeholders, the project partners led a series of workshops with each of the sector groups between January and July 2012 during which participants examined projected climate impacts, internal adaptive capacity, and needs and opportunities for adaptation action. Some of the strategies that were developed during these sector group meetings include improving water infrastructure and efficiency standards, enhancing information and education of the citizenry, employing green infrastructure techniques, and incorporating climate change into regulations and permitting. The project partners plan to reconvene all of the sector groups to share their strategies and evaluate the project's results.

Saving Water Saves Energy

This project aims to educate households, businesses, and watershed organizations on water conservation and efficiency. Project partners include the River Network, Alliance for Water Efficiency, and WaterSense. Project staff are conducting marketing research to craft the messaging, convening focus groups of water users in the watershed, and collecting tools and resources that can help users understand the connections between water, energy, and climate change. Some of these tools include the [Home Water Works Water Usage Calculator](#), [National Geographic's Water Footprint Calculator](#), and the [H₂OUSE Water Saver](#).

Project Outcomes and Conclusions

The HRWC has taken steps to incorporate climate change into its regular programmatic work and has expanded its efforts by targeting climate change in two projects to build capacity for climate-resilient communities and enhance water conservation and efficiency. The HRWC has faced a few challenges in these efforts. For example, some individuals and organizations have been alienated by the use of the term “climate change,” so the HRWC has stressed resilience and energy conservation in its messaging. Another challenge has been generating interest in some of the activities, specifically the Climate-Resilient Communities meetings. The HRWC is working on outreach in order to improve the number and diversity of people in attendance. They are seeking to improve communications with different stakeholders; for example, learning how to better explain why a particular project relates to the day-to-day activities of a community planner or stormwater manager.

In both of these projects, partnerships have proved to be very effective for the HRWC, especially the relationships with GLISA and the River Network. Both groups have supported the HRWC by attending and developing materials for use at the sector meetings and workshops for the Climate-Resilient Communities project, and the River Network researched and developed materials to support the water-energy-climate connection for the Saving Water Saves Energy project.

The next step for the Climate-Resilient Communities project is to bring together the three stakeholder groups to share their experiences and develop recommendations in conjunction with other affected parties, such as policymakers and funders. The HRWC is also seeking additional funding to implement the strategies developed and expand the geographic representation of participants in the watershed; they plan to incorporate monitoring and evaluation into the second phase of funding requests.

References

Huron River Watershed Council. 2009. Huron River Report: Climate Change Edition
www.hrwc.org/wp-content/uploads/2009/07/FINALWinter2009.pdf
 HRWC. Model Ordinance – Riparian Buffer: www.hrwc.org/wp-content/uploads/2009/11/HRWC_riparianbuffer_model_ordinance.pdf

Status

Information gathered from interviews with project contacts (June 15 and June 28, 2012) and other resources. Case study reviewed by project leads.

Citation

Gregg, R. M. (2012). *Building Capacity for Climate-Resilient Communities and Water Conservation in the Huron River Watershed* [Case study on a project of the Huron River Watershed Council]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts

Policy: Create new or enhance existing policies or regulations

Natural Resource Management and Conservation: Reduce local climate or related change

Infrastructure, Planning, and Development: Community planning (developing climate-smart communities)

Canada's Regional Adaptation Collaboratives Climate Change Program

By: Kirsten Feifel

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Project Summary/Overview

The Regional Adaptation Collaboratives (RAC) Climate Change Program was designed to help Canadian communities prepare for and adapt to the regional impacts of climate change. The six RACs work with federal, provincial, local, and community partners to identify climate-related issues and develop place-specific solutions to mitigate adverse impacts in the future. The RAC Program and associated projects are scheduled to conclude in December 2012.

Project Background

The RAC Program's goal is to promote climate change adaptation planning in Canadian communities; there are six regional initiatives – British Columbia, Prairies, Ontario, Quebec, Atlantic, and Northern. Created by the Government of Canada and managed by Natural Resources Canada's (NRCan) Climate Change Impacts and Adaptation Division, the program received an initial commitment of \$30 million over three years to support regional efforts to develop tools that local decision-makers could use to inform and reduce their risks to climate change. It is supported by the participation of over 125 partners in federal, provincial, and local governments, industries, Aboriginal cultures, and non-governmental organizations.

Project Implementation

The design of the RAC centers was developed out of a recognition of the need to take a regional approach to adaptation; activities at a broader scale are often difficult to initiate as climate change impacts will be felt differentially based upon locale. Further, there exists a place-specific knowledge base among regional academics, government agencies, and local communities. The RACs promote local projects that help decision-makers integrate adaptation measures into regional planning, policies, and programs. Results and lessons learned from these projects are then shared with other RACs.

The RACs' targeted goals are a direct response to a 2007 NRCan research report, *From Impacts to Adaptation: Canada in a Changing Climate*. Each RAC has different focus areas based upon predicted impacts and local concerns. They are as follows:

- British Columbia RAC ([Preparing for Climate Change: Securing British Columbia's Water Future](#)): water allocation and use, forest and fisheries management, flood protection, community adaptation
- [Prairies RAC](#): water supply and demand, drought and flood planning, forest and grassland ecosystems

- [Ontario RAC](#): extreme weather risk management, water management, community adaptation
- [Quebec RAC](#): built environment, water management, forestry, agriculture, tourism and recreation
- Atlantic RAC ([Atlantic Climate Adaptation Solutions Project](#)): community planning for flood and coastal areas, groundwater protection, capacity enhancement
- [Northern RAC](#): vulnerability of mining and development of good environmental practices for northern exploration and mining

Project Outcomes and Conclusions

The RACs have produced new decision-making tools, knowledge, and enhanced networks capable of helping local communities and regions adapt to climate change. Outcomes vary by RAC because the impacts of climate change will be different, requiring place-specific initiatives and strategies. The RAC Program is ending in December 2012. NRCan is initiating a new program that will build on the efforts of the RACs called the Adaptation Platform (2011-16).

References

- Lemmen, D.S., Warren, F.J. & Lacroix, J. (2007). From Impacts to Adaptation: Canada in a Changing Climate 2007. Ottawa, Ontario, Canada: Natural Resources Canada.
www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/assessments/132
- RAC Program Fact Sheet
www.nrcan.gc.ca/sites/www.nrcan.gc.ca/earth-sciences/files/pdf/collab/pdf/racfactsheet_e.pdf

Status

Information gathered through online resources and communication with project contact.

Citation

Feifel, K. M. (2012). *Canada's Regional Adaptation Collaboratives Climate Change Program* [Case study on a project of Natural Resources Canada]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments

ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State

By: Rachel M. Gregg

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Project Summary/Overview

The New York State Energy Research and Development Authority (NYSERDA) is engaged in both climate change mitigation and adaptation efforts. The ClimAID project assessed both climate change impacts and adaptation options for the state. Project researchers downscaled climate projections for different regions of New York in order to identify likely impacts; in addition, the team developed adaptation strategies and recommendations for action, which were released in the 2011 report, [*Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation*](#).

Project Background

NYSERDA's Environmental Monitoring, Evaluation, and Protection (EMEP) Program aims to “increase the understanding and awareness of the environmental impacts of energy choices and emerging energy options, and provide a scientific, technical foundation for formulating effective, equitable, energy-related environmental policies and resource management practices.” EMEP develops five-year research plans that guide the program's efforts; the last plan was released in 2007, which added climate change as a topic under the purview of EMEP. External experts were brought in to help EMEP program staff determine priorities for projects focused on climate change; from these discussions, two urgent priorities were identified – development of greenhouse gas mitigation strategies and an assessment of climate change impacts and adaptation options. EMEP released a solicitation seeking proposals to address each of these needs; a proposal submitted by Columbia University, Cornell University, and the City University of New York (CUNY) was funded by NYSEDA in 2008 to fulfill the impacts and adaptation assessment component. This project – ClimAID – was led by Cynthia Rosenzweig (Columbia University, NASA Goddard Institute for Space Studies), Arthur DeGaetano (Cornell University, Northeast Regional Climate Center), and William Solecki (CUNY Institute for Sustainable Cities), and managed by Amanda Stevens at NYSEDA. The larger project team included more than 50 academic researchers.

Project Implementation

ClimAID was an impacts and adaptation assessment for the entire state. Working closely with stakeholders and coordinating with existing initiatives, such as the [*New York State Sea Level Rise Task Force*](#), New York City's Climate Change Adaptation Task Force and Panel on Climate Change, and [*Rising Waters*](#), the project team examined five themes (Climate, Vulnerability, Adaptation, Equity and Environmental Justice, and Economics) across eight sectors (water resources, coastal zones, ecosystems, agriculture, energy, transportation, telecommunications, and public health).

Although a statewide assessment, ClimAID considered the diversity of New York State and that such diversity may result in some variation in impacts and adaptive capacity in different regions of the state.

The project researchers divided by expertise into eight sector teams. Each sector was tasked with examining the five major themes as they related to their sector:

- Climate: Given future climate scenarios and changes in specific climate variables, which of those changes could affect the sector the most? (e.g., Is there likely to be an increase in drought, and would it be relevant to the agricultural sector? What about a decrease in snow cover?) What climate indicators in the sector could help monitor the effects of the changing climate?
- Vulnerability: How will the changing climate impact the sector in each of the state's regions? Which aspects of the sector are vulnerable to these changes and how will they be affected? (e.g., What would be the impact of increased drought on agriculture?) Each sector used literature reviews and expert opinion to develop assessment criteria, which included magnitude, timing, persistence, and likelihood of the impact, among others.
- Adaptation: What are some actions that the sector could take to prepare for the future climate? Are there opportunities to become more resilient to both current and future climate hazards? (e.g., Might farmers plan to switch to drought-tolerant crop varieties?) The team used expert and stakeholder opinion to examine both existing and potential adaptation strategies, while also identifying research gaps and monitoring needs that, if addressed, would ease implementation and increase likelihood of success.
- Equity and Environmental Justice: Are there inequalities in how climate change may impact the sector? Are there specific groups of people (or species) within the sector who would be more vulnerable to particular impacts of climate change or who would be particularly affected by certain adaptation options? (e.g., Might small family farms be more vulnerable in the agricultural sector than larger farms?)
- Economics: What is the economic value of the sector and what are the potential costs and benefits of climate impacts and adaptation strategies? (e.g., How might the dairy industry be economically affected by the changing climate?)

The project also included a team of researchers for each theme, who made specific contributions to each of the eight sectors and ensured consistency across the sectors:

- The Climate group analyzed past and future climatic conditions in the state using data from NOAA's Northeast Regional Climate Center and assessed model simulations from the North American Regional Climate Change Assessment Program. They developed projections for the state as a whole and downscaled data for seven regions of the state. The regions were delineated based on climate type, ecosystem characteristics, and economic activities. Projections were assigned confidence level ratings developed for the Intergovernmental Panel on Climate Change's Fourth Assessment Report (e.g., "extremely likely," "very likely," etc.).
- The Vulnerability and Adaptation groups assessed both short and long-term vulnerabilities and provided overarching expertise to each sector. The team used literature reviews and expert opinion to develop assessment criteria for each sector.

- The Equity and Environmental Justice group used literature reviews, case studies, and expert stakeholder engagement to examine equity issues relevant to each sector, identifying populations who may be particularly vulnerable to the impacts of climate change.
- Using case studies for each sector, the Economics group engaged with stakeholders to create a list of potential impacts and adaptation strategies; these were then ranked in a cost-benefit analysis (estimates created using standard pricing and discount rate measures) over short (0-5 years), medium (5-15 years), and long-term (15+) periods.

Each sector also included one or more case studies, each of which explored a particular aspect of the sector in more detail.

To ensure that the project results would be relevant to those making real-world decisions, several steps were taken to incorporate input from stakeholders intimately involved with each of the sectors. NYSERDA convened a Project Advisory Committee (PAC) at the start of the project, composed of experts in climate change and the sectors. The PAC met several times throughout the project to review draft materials and provide input to the project direction as a whole.

Each of the eight sectors also convened their own groups of stakeholders. These stakeholder groups were composed of individuals from public, private, and nonprofit organizations with knowledge and experience in that sector, providing each sector with input and feedback throughout the process.

All of the research and recommendations were incorporated into the 2011 report, [*Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation*](#).

Project Outcomes and Conclusions

The ClimAID report served as the scientific basis for the climate science and adaptation portions of the Interim Report of the [New York State Climate Action Plan](#). Currently, the project team is engaged in outreach in order to get the ClimAID information to both the people who are most affected and those who have the capacity to take action. The report received extensive press when it was released, and several conferences and workshops have since been held focusing on the project results and next steps.

ClimAID was a first step in helping New York State prepare for the impacts of climate change. To continue the effort, in mid-2012 NYSERDA released a solicitation for proposals for adaptation research that would fill some of the knowledge gaps identified in both ClimAID and the Interim Report of the Climate Action Plan. Contract negotiations are underway with several of the resulting projects.

Throughout their efforts, NYSERDA's framing of climate change adaptation has been primarily focused on climate-smart planning. They are conscious of messaging when talking to different groups, especially with regards to focusing outreach on distilling information to local communities and providing science-based guidance to individuals, agencies, and organizations looking to incorporate climate change considerations into existing practices, policies, and programs.

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Status

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Citation

Gregg, R. M. (2012). *ClimAID: Developing a Climate Change Impacts and Adaptation Assessment for New York State* [Case study on a project of the New York State Energy Research and Development Authority]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts

Policy: Develop/implement adaptation plans

Climate Adaptation in the City of Ann Arbor, Michigan

By: Jessi Kershner

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Project Summary/Overview

Climate impacts within the Great Lakes region include warmer temperatures, changes in precipitation, and increased frequency and intensity of storms, which are likely to affect human and natural systems in significant ways. The City of Ann Arbor, located in southeast Michigan, has been and continues to be a climate leader within the region, and is currently implementing myriad strategies to incorporate climate into planning efforts.

Project Background

In the Great Lakes region, average temperatures have increased by 2.3°C from 1968 to 2002; by 2100, climate projections suggest that average temperatures will be 3.6 to 11.2°F higher (GLISA 2012). Changes in precipitation are much less clear – annual average precipitation is likely to increase or remain stable while winter and spring precipitation may increase more significantly. Increased frequency and intensity of severe storms are also projected to occur (GLISA 2012). Climate changes are likely to impact human health by increasing heat stress, particularly in urban areas where infrastructure and impervious surfaces trap heat, resulting in higher temperatures (e.g., urban heat island effect). Warmer temperatures and changes in precipitation are also likely to affect forests by potentially increasing pests and diseases, increasing forest fire frequency, or causing certain tree species to no longer survive in the region. Precipitation changes and increased frequency and severity of storms are also likely to impact aging stormwater infrastructure, resulting in more combined sewer overflows and pollution (Bergquist et al. 2012).

The City of Ann Arbor, located in southeast Michigan, is the sixth largest city in the state with a population over 112,000 people. Ann Arbor is a climate leader within the Great Lakes region, having signed the [U.S. Conference of Mayors Climate Protection Agreement](#) to reduce greenhouse gas emissions and promote policies to address climate change; it is also an active member of ICLEI-Local Governments for Sustainability and as such, is committed to engaging in sustainability, climate protection, and clean energy initiatives. The city is engaged in numerous efforts to incorporate climate adaptation into planning efforts.

Project Implementation

The City of Ann Arbor has not developed an independent climate change adaptation plan. Instead, they have focused on creating a set of priorities through a sustainability lens, wherein climate adaptation is integrated (although not always explicitly called out) in current city planning. For example, Ann Arbor is working on incorporating climate projections into its [urban forestry plan update](#) in order to assess the effects that changing climate conditions may have on tree species being considered for planting. Scientists at the Great Lakes Integrated Sciences and Assessments Center

(GLISA) have provided downscaled temperature and precipitation projections to city staff in order to get a sense of what changes have occurred and what changes are likely to occur in the future. For example, climate information could be used to plant a diversity of species resilient to potential impacts, with the intention of avoiding a catastrophic loss of forest. City staff are currently going through the draft urban forestry plan and identifying places to add in climate, as well as incorporating an assessment and monitoring component to look for indications that changes in climate are affecting the urban forest.

Using a grant from Home Depot, the City of Ann Arbor has developed a Sustainability Framework, which integrates goals from all (~27) of Ann Arbor's planning documents. The Framework is organized into four theme areas: Land Use and Access, Climate and Energy, Community, and Resource Management, and includes 16 sustainability goals. The purpose of the Sustainability Framework is to organize 20 years of planning into a core set of 16 goals that will be integrated into the Master Plan in Fall 2012 and used across the organization. Mitigation efforts fall under the Energy Conservation goal and Adaptation efforts fall under the Safe Community goal.

The city is also working on numerous other projects including a health impact assessment in low-income neighborhoods, updating their [Climate Action Plan](#), and a unique financing mechanism to reduce stormwater input and fund major improvements. The city is working with the county health department and the University of Michigan to research whether planting trees in low-income neighborhoods is likely to reduce health impacts associated with warmer temperatures. The city is also working on updating its Climate Action Plan, which is mostly focused on mitigation but does contain some adaptation strategies. In its update, staff are considering listing specific adaptive activities so they are poised to take advantage of funding or other opportunities when they arise. Ann Arbor credits residents' stormwater utility bills if they install green infrastructure such as rain barrels, rain gardens, and porous pavers to reduce the amount of stormwater entering the sewer system. The city uses the amount of pervious and impervious surfaces on a property to determine stormwater rates.

The City of Ann Arbor is engaged in many other adaptation-related activities, which can be found in Bergquist et al. (2012). Additionally, they sent several staff to the Institute for Sustainable Communities' Climate Leadership Academy for training to help identify relevant mitigation and adaptation tools and resources to support staff in understanding how climate change could affect the programs they manage.

Project Outcomes and Conclusions

The City of Ann Arbor is engaged in many "adaptive" projects that are not specifically called out as "climate adaptation". The city believes that integrating the best available climate science into each planning effort is preferable to developing a stand-alone adaptation plan. The city is working with local universities to develop accurate climate planning scenarios that can then be integrated into current planning efforts. There are existing planning processes for many of the systems managed by the city and integrating the best climate data into these processes is least disruptive and likely to have the greatest benefit to educating staff and developing the best plans.

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Status

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Citation

Kershner, J. M. (2012). *Climate Adaptation in the City of Ann Arbor, Michigan* [Case study on a project of the City of Ann Arbor]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct training and planning exercises

Policy: Create new or enhance existing policies or regulations

Infrastructure, Planning, and Development: Community planning (developing climate-smart communities), Create or modify shoreline management measures

Climate Change Adaptation Planning at the State Level in Minnesota

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Project Summary/Overview

The Minnesota Interagency Climate Adaptation Team (ICAT) and the state Climate Change Adaptation Working Group (CCAWG) are complementary initiatives designed to address and develop responses to the effects of climate change. These groups and their members are developing and implementing strategies to advance climate change adaptation in the state in order to limit negative effects, take advantage of potential opportunities, and improve the resilience of natural and human systems in a changing climate.

Project Background

Minnesota contains 11,842 lakes over 10 acres in size, 6,564 natural rivers and streams that flow approximately 69,200 miles, and a total surface water area of 13,136,357 acres; these freshwater bodies drain into the Hudson Bay watershed, the Atlantic Ocean, and the Gulf of Mexico (MDNR 2008). The economy is incredibly diverse, represented by agriculture, forestry, mining, manufacturing, recreation, tourism, and energy, among others. Climate change may have both positive and negative effects on the state's natural, human, and built systems. These primary and secondary impacts include increases in temperatures, flooding, diseases, droughts, and wildfires; biodiversity and habitat loss; longer growing and allergy seasons; more extreme heat and weather events; lower lake levels; and increasing energy demand and usage.

Recognizing these projected impacts, Minnesota formed the ICAT in 2009, which is composed of representatives from the Pollution Control Agency and the Departments of Natural Resources, Commerce, Public Safety, Health, Agriculture, and Transportation. ICAT operates in conjunction with the state CCAWG, led by the University of Minnesota's Water Resources Center. Members of the CCAWG include representatives from the state Departments of Natural Resources, Health, and Transportation and the Pollution Control Agency, *Metropolitan Mosquito Control District, National Oceanic and Atmospheric Administration, U.S. Geological Survey, U.S. Army Corps of Engineers, cities and counties, the University of Minnesota, nonprofits, and the private sector.*

Project Implementation

ICAT began examining projected climate impacts in July 2009 and released [*Adapting to Climate Change in Minnesota*](#) in fall 2010; the report includes a description of projected climate change impacts and adaptation examples from different state agencies.

The CCAWG comprises representatives from federal, regional, state, and local governments, nonprofits, academia, and the private sector that work together to advance adaptation through research and education. The CCAWG operates under seven priorities and associated goals and strategies:

1. **Assess needs** for research, education, outreach, collaboration, and monitoring by synthesizing information on existing adaptation efforts, identifying knowledge gaps and data needs, and determining priorities to support collaboration on adaptation initiatives.
2. **Advance adaptation research** by identifying financial and partnership opportunities and coordinating information sharing around research activities.
3. **Act as an information clearinghouse** by creating an engaged and informed network of practitioners and a space for information sharing.
4. **Communicate policy and management recommendations** by producing impacts and adaptation synthesis reports and collaborating with other Midwest states.
5. **Provide education** by engaging the public, promoting climate adaptation, and hosting conferences, workshops, and webinars.
6. **Inform decision makers and the public** by coordinating information dissemination and providing management recommendations.
7. **Evaluate outcomes** by developing and applying performance metrics and indicators for adaptation success.

Project Outcomes and Conclusions

ICAT and the CCAWG are the primary consortiums leading climate adaptation efforts in Minnesota. Many initiatives by these groups and their members have either been completed or are underway; for example:

- ICAT is coordinating activities among the state departments and actively collaborates with the CCAWG. Some activities that have been identified as priorities include developing better projection tools, identifying and assessing vulnerability and risk, increasing information sharing and exchange, enhancing trainings and capacity building, developing and applying a climate monitoring framework to support the tracking of climate impacts and management actions, and developing a long-term climate adaptation plan for the state.
- The CCAWG has been meeting regularly since June 2008 and sponsored the 2010 [Clean Water and Climate Adaptation Summit](#) with the Minnesota Landscape Arboretum and the Minnehaha Creek Watershed District. This two-day event focused on green infrastructure and climate change adaptation, including presentations and discussions on impacts, climate models, possible challenges for management, and potential solutions. The group hosts regular climate seminars and utilizes a web-based platform ([Ning](#)) through which participants network and communicate.
- The Minnesota Department of Health formed an internal adaptation working group, which created a five-year [Strategic Plan to Adapt to Climate Change](#) in 2010. The plan identifies six goals: (1) researching, monitoring, and reporting on climate-related public health impacts; (2) developing mitigation and adaptation strategies and tools to support decision making and planning related to public health and climate change; (3) identifying at risk populations; (4) improving emergency and disaster response planning and preparedness; (5) increasing adaptive capacity; and (6) communicating with and educating practitioners, decision makers, and the public on the effects of climate change on public health and safety.
- The Department of Agriculture created an Air Quality Team to coordinate and communicate on activities affecting air quality, including climate change.

- The Department of Public Safety is developing adaptation goals to include in the state's hazard mitigation plan.
- The Department of Natural Resources has included climate change mitigation, adaptation, and monitoring as part of its Strategic Conservation Agenda. This includes preserving lands and forests that can uptake and store greenhouse gases, creating wildlife corridors and enhancing connectivity to facilitate species movement, and monitoring climate change impacts and evaluating the efficacy of mitigation and adaptation measures. The department runs the [Sustaining Lakes in a Changing Environment \(SLICE\)](#) program, which monitors lake conditions in response to impacts from land use patterns and climate change, and is conducting a vulnerability assessment of species and habitats that will be incorporated in to the [State Wildlife Action Plan](#).

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Status

Information gathered from interview with project contact June 20, 2012 and other resources.

Citation

Gregg, R. M. & Hitt, J. L. (2012). *Climate Change Adaptation Planning at the State Level in Minnesota* [Case study on a project of the Interagency Climate Adaptation Team and the Climate Change Adaptation Working Group]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools, Monitor climate change impacts and adaptation efficacy

Policy: Develop/implement adaptation plans, Create new or enhance existing policies or regulations

Natural Resource Management and Conservation: Enhance connectivity and areas under protection

Infrastructure, Planning, and Development: Community planning (developing climate-smart communities), Develop disaster preparedness plans and policies

Climate Change Adaptation Planning at the State Level in Pennsylvania

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Project Summary/Overview

Pennsylvania has taken a number of steps to address the effects of climate change on the state's natural and built environments. In addition to the creation of an advisory committee to guide climate change action, Pennsylvania has conducted a statewide impacts assessment and completed a climate action plan. These activities have formed the basis for adaptation strategies to be developed and implemented to varying degrees of success thus far.

Project Background

Climate change is already happening in Pennsylvania and impacts are projected to continue and worsen; these include increases in temperatures, precipitation variability, flooding, and storm events. The state's 2008 [Climate Change Act](#) mandated the creation of a Climate Change Advisory Committee (CCAC), an impacts assessment, and a climate action plan.

The CCAC, responsible for implementing the provisions of the Climate Change Act, comprises five sub-committees representing Electricity Generation, Transmission, and Distribution; Industry and Waste; Residential and Commercial; Land Use and Transportation; and Agriculture and Forestry. Members serve four-year terms and may be appointed by the state Governor, Senate, and House of Representatives.

The Department of Environmental Protection commissioned an impacts assessment that was released in 2009 (Shortle et al. 2009). The report examines likely effects on water resources, forests, wildlife, fisheries, aquatic habitats, agriculture, energy, human health, tourism and recreation, and the economy. This report informed the preparation of the [Pennsylvania Climate Change Action Plan](#); the plan was released in December 2009 and by law must be updated every three years. The recommended target of the plan is a 30% reduction in greenhouse gas emissions below 2000 levels by 2020; in order to achieve this target, the plan includes over 50 specific mitigation recommendations. In addition, the plan calls for the development of climate change adaptation measures to be developed and implemented concurrently with mitigation actions.

Project Implementation

These activities led the CCAC to commission the development of an adaptation planning report. The CCAC created four sector-specific working groups in 2010 to develop adaptation strategies;

each group – Infrastructure, Public Health and Safety, Natural Resources, and Tourism and Outdoor Recreation – was led by two to three co-chairs representing government and non-governmental interests. These groups identified potential impacts to and vulnerabilities of each sector and developed recommendations for adaptation action. Examples of recommendations include to:

- Implement integrated water resource management
- Encourage water conservation and efficiency
- Enhance data collection and dissemination
- Integrate climate change into existing policies and plans
- Implement monitoring of climate change impacts and evaluation of management actions
- Increase climate change education and outreach
- Implement green infrastructure techniques
- Include climate change adaptation criteria in grant programs

The working group reports were combined into the [*Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations*](#), released in 2011.

Project Outcomes and Conclusions

The recommendations from the *Climate Adaptation Planning Report* will be incorporated into the next version of the Climate Change Action Plan. Other natural resource-focused adaptation activities have also occurred or are in progress in the state. For example,

- In 2009, staff from the Department of Conservation and Natural Resources (DCNR), Pennsylvania Game Commission, Pennsylvania Fish and Boat Commission, and The Nature Conservancy conducted interviews with representatives from local, state, and federal agencies and non-governmental organizations about climate change adaptation. The results of these interviews, including perspectives and recommendations on how climate change adaptation strategies could be developed and implemented in the state, were synthesized in the report [*Weathering Climate Change: Framing Strategies to Minimize Impacts on Pennsylvania Ecosystems and Wildlife*](#).
- The Pennsylvania Natural Heritage Program, a partnership of the DCNR, Western Pennsylvania Conservancy, Pennsylvania Fish and Boat Commission, and Pennsylvania Game Commission, worked on a project to assess the vulnerability of different species in the state to climate change. This project was funded by the DCNR's Wild Resource Conservation Program. Using the NatureServe Climate Change Vulnerability Index, staff assessed the vulnerability of 85 species by considering effects on dispersal ability, genetic variation, and habitat vulnerability, among others. The final report concluded that climate change will have both negative, positive, and neutral effects on different species in the state, and that more extensive assessments on a larger quantity of species are needed (Furedi et al. 2011).
- Along with other U.S. states, Pennsylvania is working to incorporate climate change into its State Wildlife Action Plan (SWAP). The 2005 version of the plan acknowledged climate change as an issue of concern for wildlife and habitats in the region but did not specifically provide any action items. A 2009 amendment to the plan specifically addresses climate change and its effects on wildlife management in the state (Pennsylvania Game Commission and Pennsylvania Fish and Boat Commission 2009). The amendment includes a discussion of impacts, conservation and management implications, and potential adaptation strategies. Strategies mentioned include reducing non-climate stressors, protecting biodiversity and

ecological function, maintaining/restoring natural habitats and connectivity, and applying adaptive management practices. More research on climate change and its effects on the state's species and habitats, along with adaptation strategies, will be incorporated into the updated SWAP, expected in 2015.

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Status

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Citation

Gregg, R. M. (2012). *Climate Change Adaptation Planning at the State Level in Pennsylvania* [Case study on a project of the Pennsylvania Departments of Environmental Protection and Conservation and Natural Resources]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments

Policy: Create new or enhance existing policies or regulations, Develop/implement adaptation plans

Climate Change and Coastal Adaptation Options for the Great Lakes

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Project Summary/Overview

In 2003, a collaborative effort was launched to assess the likely impacts climate change may pose to communities in Ontario living in the coastal zones of the Great Lakes and develop adaptation options. Information was gathered using extensive literature reviews, public workshops, and modeling. The data and adaptation options were discussed with the public via five workshops held throughout the Great Lakes Ontario region. A final [report](#) was released in 2006. It provides information for specific sites located throughout the region and details current status, uses, and management practices, likely climate-related impacts, and potential adaptation strategies.

Project Background

The Great Lakes basin will be affected by the impacts of climate change through changes in temperatures, precipitation patterns, forms, and intensities, lake levels, and other associated consequences. Temperatures are expected to rise by 2-5°C, precipitation is expected to increase with more falling in the form of rain rather than snow, and lake levels may lower due to increased evaporation rates throughout the 20th century (AMEC 2006). These changes will have cascading effects, altering the natural environments and affecting human populations within the coastal zone of the Great Lakes.

Approximately 31% of Canada's population calls the Great Lakes basin home, living in major cities such as Toronto or smaller cities such as Hamilton, Sarnia, Windsor, and Thunder Bay (AMEC 2006). The populace garners multiple sources of income related to the vast networks of freshwater streams and lakes associated with the Great Lakes basin, including marine transportation and shipping, recreation and tourism, fisheries, and agriculture.

As climate change begins to impact the natural and built environments of the Great Lakes, adaptation options will be necessary elements for the continued success of the region. Adaptation recommendations will vary based upon the impact being mitigated, cost of mitigation, and time of implementation. A 'one size fits all' prescription will not suffice because communities vary in size and location and are affected by compounding factors.

The project's goal was to "identify coastal features and processes on the Great Lakes which are likely to be affected by climate change and to determine sustainable management practices that will reduce the vulnerability of these features and processes" (AMEC 2006).

Project Implementation

This project was a collaborative effort between AMEC Earth and Environmental, Ontario Ministry of Natural Resources, Toronto and Region Conservation Authority, Canadian Wildlife Service, Natural Resources Canada, and Environment Canada. The principal investigators had various

expertise in disciplines including hydrology, wildlife, aquatic habitat, lake and terrestrial biology, and climate modeling. Jurisdictional managers from different municipalities, agencies, and non-governmental organizations were identified as key participants because they implement much of the coastal management strategies employed in the region. The project was funded by Natural Resources Canada through the Climate Change Action Fund and in-kind donations from the project partners.

The project was initiated in 2003 and had three phases to its timeline. Year 1 (2003) was devoted to data collection, Year 2 (2004) to modeling, and Year 3 (2005) to assessing adaptation options. Data collection was done through a literature review of adaptation strategies consisting of traditional library searches as well as input from government officials and other stakeholders. During the data collection stage, climate change impacts were given a geographic limitation but adaptation measures were considered from around the world. Models were then used to ascertain the potential effects that changes in climate drivers might have on the region's physical and biological processes. Finally, results from the literature review and the modeling experiments were discussed in workshops held in coastal communities from Lakes Ontario, Erie, Huron and Superior. Community input was received from universities, NGOs, municipalities, agencies, First Nations communities, and industry representatives during all three phases of the project.

To bring together speakers, local representatives, and regional scientists, five workshops were held between 2003 and 2005 to discuss and identify the potential impacts of climate change and related adaptation options. Attendees were invited based upon their expertise, business area, and local interests. An effort was made to make each of the five workshops unique in content and to provide a “bottom-up,” multi-stakeholder approach to examining the issues that climate change may present to communities. Roughly 250 people attended the workshops that were held in Belleville, Parry Sound, Long Point, Sault Ste. Marie, and Toronto. The presentations and a list of workshop attendees were documented in accompanying CDs for broader distribution. More detailed workshop information can be found at the [project website](#).

Project Outcomes and Conclusions

The final report, *Coastal Zone and Climate Change on the Great Lakes*, synthesizes all the information gathered throughout the three-year project. Information is provided on the case study sites in the selected regional areas surrounding Lakes Ontario, Erie, Huron, and Superior. Particular focus is given to the Toronto Area of Concern, Hamilton Area of Concern, Presqu'île Provincial Park, Long Point Important Bird Area, Point Pelee National Park, St. Clair Marshes Important Bird Area, Goderich Harbour, Sturgeon Bay, Thunder Bay Area of Concern, Pukaswa National Park, and Sault Ste. Marie. Each case study description includes physical and biological characteristics, and information on recreational uses, existing land use planning and management, likely climate change-related impacts, and adaptation options. Finally, the report concludes with a high-level discussion of the climate change impacts may present to agriculture, fisheries, forestry, power generation, recreation, transportation, and wildlife.

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Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *Climate Change and Coastal Adaptation Options for the Great Lakes* [Case study on a project of AMEC Earth and Environmental]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Increase/improve public awareness, education, and outreach efforts, Conduct research, studies, and assessments, Conduct training and planning exercises

Climate Change Mitigation and Adaptation Planning in Wisconsin's Lake Michigan Coastal Communities

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Project Summary/Overview

As part of its mission, the Bay-Lake Regional Planning Commission (Bay-Lake RPC) provides hazard mitigation planning support to the coastal communities along Lake Michigan and Green Bay in Wisconsin. The region's shorelines are shaped by natural, dynamic processes including erosion and accretion; climate change is projected to increase erosion as lake levels and ice cover decrease and wind and wave action increase. Damage to the natural environments and built infrastructure along the shoreline will likely increase as a result. In response, the Bay-Lake RPC has worked to educate and provide guidance to local communities in order to plan for and mitigate climate-enhanced coastal hazards.

Project Background

Coastal erosion in the Great Lakes is influenced by changes in lake levels, storms, and longshore sediment transport (Coastal Communities Working Group 2010). Erosion is expected to be exacerbated by declining lake levels and ice cover and increasing wind strength, wave action, and flooding (WICCI 2011). Associated impacts to natural and built systems in the region include property damage, habitat degradation, pollution, and other coastal hazards; these impacts require coordinated planning approaches to mitigate damage.

The Bay-Lake RPC supports the planning efforts of local governments in northeastern Wisconsin, including eight counties (Brown, Door, Florence, Kewaunee, Manitowoc, Marinette, Oconto, and Sheboygan), 17 cities, 40 villages, 119 towns, and the Oneida Nation. The region contains approximately 400 miles of shoreline along Lake Michigan and Green Bay. As part of its mission, the Bay-Lake RPC assists local coastal communities in hazard mitigation planning. Motivated by a noticeable lack of climate change information incorporated into local hazard mitigation plans, staff at the Bay-Lake RPC began focusing on ways to increase support and provide information to local coastal communities with financial support from the National Oceanic and Atmospheric Administration and the Wisconsin Coastal Management Program.

Project Implementation

The Bay-Lake RPC incorporated climate change into the 2007 [*Guide for Hazard Mitigation Planning for Wisconsin Coastal Communities*](#) and began educating managers and planners on climate change impacts. The guide encourages practitioners to develop multi-hazard mitigation plans that integrate projected increases in the intensity and frequency of events, such as temperature extremes, storms, floods, and droughts.

Project Outcomes and Conclusions

The Bay-Lake RPC provides guidance on hazard mitigation planning to local coastal communities along Lake Michigan. In addition, the RPC wants to expand their efforts to educate these communities about the effects of climate change and incorporate adaptive responses into planning and policy. The Bay-Lake RPC is seeking a pilot community with which to develop mitigation and adaptation strategies and an action plan to prepare for climate change, and then reproduce this effort in other local coastal communities. Challenges to this effort include communities that are reluctant to address climate change and a lack of financial capacity.

References

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Status

Information gathered from project contact's survey responses on March 3, 2011, publications, and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Climate Change Mitigation and Adaptation Planning in Wisconsin's Lake Michigan Coastal Communities* [Case study on a project of the Bay-Lake Regional Planning Commission]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Infrastructure, Planning, and Development: Community planning (developing climate-smart communities), Develop disaster preparedness plans and policies

*Climate Change, the Great Lakes, and Mining*²⁵⁶

By: Kirsten Feifel and Emily Whittaker

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Project Summary/Overview

In 2006, Kennecott Minerals applied for permits to develop a mine in the Yellow Dog Plains located in Michigan's Upper Peninsula. To garner support for enhanced environmental protection, the Yellow Dog Watershed Preserve, a watershed protection group, solicited a report to assess the impacts climate change may pose to regional mining practices. The report reviews climate change projections and impacts and then attempts to assess how this will affect the mining industry and its environmental footprint.

Project Background

The climate is already changing in the Great Lakes region. In general, the climate is becoming wetter and warmer, primarily in the cold season. This has manifested in warmer winters, earlier spring melts, and lower surface water levels in summer and fall. These changes have the potential to negatively affect the mining industry, as well as other energy and water-intensive users.

In 2002, the Kennecott Minerals Corporation, a subsidiary of Rio Tinto, found ore deposits of copper, gold, and nickel in Michigan's Upper Peninsula near productive salmon streams. Local citizens were concerned because the ore deposits were surrounded with sulfide, which, when exposed to air and water, transforms into sulfuric acid; mining activities therefore could present dire consequences to the local watershed and surrounding environment. Despite concerns, Kennecott Minerals was awarded a permit to begin mining the ore deposits and construction began in 2010. In an effort to preserve the region's environmental integrity, the Yellow Dog Watershed Preserve, a local watershed protection group, sponsored a report to assess the impacts that climate change may pose to the Kennecott mining industry.

Project Implementation

The study was funded through a grant with Freshwater Future. The report was written by an outside contractor who conducted personal interviews with climate scientists and mining companies and reviewed existing literature. The goal of the report was to provide talking points that would allow the Yellow Dog Watershed Preserve to leverage changes in regional mining practices.

Though not meant to be comprehensive, the report reviews much of the available relevant literature to determine how regional climate change is projected to affect the mining industry, the environment, and humans in the Great Lakes region, and its potential effects on the Eagle Mine in Marquette County, Michigan. It offers recommendations to groups interested in protecting the

²⁵⁶ Also available at <http://www.cakex.org/case-studies/5190>

environment and human health from the regional effects of climate change. Kennecott Eagle Minerals did not noticeably consider climate change impacts in their Eagle Mine design or during their permitting process. The Yellow Dog Watershed Preserve plans to use the report to initiate a discussion with regional leaders and politicians in the hopes of encouraging Kennecott Eagle Minerals to revise its environmental protection plans. The Yellow Dog Watershed Preserve hopes that improvements made in the mine plan in light of climate change would also help to safeguard the watershed.

Project Outcomes and Conclusions

Mining is a large part of the historical economic vitality of the Upper Peninsula of Michigan. However, mining also has the potential to significantly affect the natural environment, creating the need for mining regulations to be reevaluated and revised to incorporate climate change impacts into future and current mine designs. The Yellow Dog Watershed Preserve is beginning to contact state and local lawmakers to raise awareness of the need for immediate inclusion and implementation of climate-related impacts in all mining regulations. Initially the group wanted to take the report to local municipalities, but a 2009 law has limited local authority and intervention in mining operations. Their focus is now on the State of Michigan, specifically the Upper Peninsula. The Yellow Dog Watershed Preserve sent a letter to local municipalities and federal and state representatives to raise awareness about the report.

References

Yellow Dog Watershed Preserve. (2011). *Climate Change, the Great Lakes, and Kennecott's Eagle Mine*. www.cakex.org/sites/default/files/project/documents/climate%20change%20YDWP_0.pdf

Status

Initial information submitted by user. Follow up interview with project contact on May 31, 2012.

Citation

Feifel, K. M. & Whittaker, E. (2012). *Climate Change, the Great Lakes, and Mining* [Case study on a project of the Yellow Dog Watershed Preserve]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Increase/improve public awareness, education, and outreach efforts

Policy: Create new or enhance existing policies or regulations

Climate Consortium for Research Action and Integration (CC-RAI)

By: Rachel M. Gregg

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Project Summary/Overview

The Climate Consortium for Research Action and Integration (CC-RAI) is an Ontario-based partnership created to facilitate regional climate change action by coordinating research, capacity building, and the provision of climate science and tools. CC-RAI is a partnership between the Toronto and Region Conservation Authority (TRCA) and York University.

Project Background

Ontario is expected to experience warmer temperatures, more frequent and intense weather events (e.g., storms, floods, heat waves), and changes in precipitation with the onset of climate change. CC-RAI was founded in 2009 by the TRCA and York University in order to build capacity in the province to address these impacts. Through CC-RAI's projects, researchers coordinate with government agencies, non-profit organizations, and private sector entities to advance climate change research and action. The existing geographic foci of the consortium include the Greater Golden Horseshoe of southern Ontario and the Great Lakes region.

CC-RAI's three programmatic goals are to: (1) foster high-quality climate research for the region, (2) build capacity of individuals and organizations, and (3) promote collaborative climate change action. CC-RAI's research framework is based around four themes:

- Science (basic research, climate modeling)
- Impacts on human and natural systems
- Solutions and policy responses (mitigation, adaptation, and energy policy)
- Communication (bridging the gap between research and practice)

CC-RAI has projects that support regional and local level climate change strategies. These include the development of the Ontario Regional Climate Change Consortium (ORCCC) as well as other pilot projects to promote climate literacy and interdisciplinary climate change research, workshops to build capacity for regional climate modeling, in addition to specific climate adaptation project developed in coordination with public and private sector organizations

Project Implementation

In 2010, CC-RAI approached 15 universities, public and private sector organizations in the province to discuss collaboration on climate change adaptation and mitigation research. Over the course of the year, these entities met to discuss and draft the [*ORCCC Strategy*](#), which was released in June 2011. The ORCCC developed out of the Ontario Region Climate Modeling Ad Hoc Committee, which was composed of representatives from academia, the public, private industries, conservation authorities, and non-governmental organizations. The Strategy identifies existing climate science and research capacity and associated research/capacity gaps in the province, and outlines how the

ORCCC can help achieve different actions outlined in the [Climate Ready: Ontario's Adaptation Strategy and Action Plan](#), including the development of climate modeling research partnerships (Action 33) and climate modeling collaboratives (Action 34).

Information and resources used by CC-RAI in their efforts include those developed by King County (Washington), Chicago (Illinois), and UKCIP.

Project Outcomes and Conclusions

CC-RAI plans to develop a research and action plan with some of the universities that participated in the development of the ORCCC Strategy. To date CC-RAI has received nine letters of support from various universities across the province with an intention of participating in the ongoing development of the Consortium. While the focus has been on bringing together a foundation of university partnership, the intention is to broaden the partnership to include collaboration with private and public sector organizations. Over the next year, CC-RAI will act as the Secretariat of the ORCCC initiative with support from TRCA and York University. Over that same time period, the ORCCC intends to work with member universities to develop a grounded climate change research plan and ultimately host a large symposium in which researchers from around the province may present their work to public and private sector stakeholders currently focused on climate mitigation and adaptation projects

While the primary thrust for CC-RAI has been the ORCCC initiative, other initiatives have included:

- University-based pilot projects focused on interdisciplinary collaboration and climate change research and climate literacy education ([Collaborating for Climate Change Literacy](#) blog);
- Climate change and design thinking – a course at the Schulich School of Business; and
- Various workshops and events, including speakers series, student research symposiums, climate change communications training, and broader educational activities (e.g. film screenings).

Additional project details are available at www.climateconsortium.ca and the soon-to-be launched www.climateontario.com

Status

Information gathered from interview with project contact July 3, 2012 and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Climate Consortium for Research Action and Integration (CC-RAI)* [Case study on a project of the Toronto and Region Conservation Authority and York University]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

*Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force*²⁵⁷

By: Rachel M. Gregg

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Project Summary/Overview

In October 2010, the U.S. Interagency Climate Change Adaptation Task Force released a series of recommendations to President Obama on how federal agencies could coordinate and collaborate on a national adaptation strategy. The Task Force released two progress reports in 2010 and 2011, and plans to continue to support implementation of the recommendations. This process represents the first steps towards a coordinated strategy for federal adaptation action on climate change.

Project Background

The Interagency Climate Change Adaptation Task Force, initiated in 2009, is co-chaired by the White House Council on Environmental Quality, the Office of Science and Technology Policy, and the National Oceanic and Atmospheric Administration. In October 2009, President Obama signed Executive Order 13541 requiring the Task Force to develop adaptation recommendations by 2010.

Project Implementation

The Task Force also created working groups to address the prospective ability of federal agencies to collaborate on adaptation responses. These groups were formed to address adaptation options in federal agencies and develop recommendations for planning and implementation focused on *Adaptation Science, Agency Adaptation Planning, Science Inputs to Policy, Insurance Adaptation, Water Resources Adaptation, Communications and Outreach, Urban, Health, International Resilience, and Plants, Fish, and Wildlife*. The working groups held over 20 listening sessions to solicit input and recommendations from stakeholders. For example, the Water Resources Adaptation working group, comprised of federal representatives from the Department of Interior, Environmental Protection Agency, and the Council on Environmental Quality, developed the 2011 [*National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*](#). This plan includes six priority recommendations to improve and guide federally-coordinated freshwater conservation and management in light of climate change: (1) create a planning process for water resources management adaptation; (2) improve information access to support decision making; (3) assess vulnerability of water resources; (4) improve water use

²⁵⁷ Also available at <http://www.cakex.org/case-studies/2750>

efficiency; (5) support Integrated Water Resources Management; and (6) increase training and outreach efforts.

In March 2010, an Interim Progress Report was released for public comment. The report focused on proposed key components to a national adaptation strategy, including:

- Integration of Science into Adaptation Decisions and Policy
- Communications and Capacity Building
- Coordination and Collaboration
- Prioritization
- A Flexible Framework for Agencies
- Evaluation

The final recommendations, released in October 2010, build upon these initial components. The report recommends the following actions:

- Institutionalize adaptation as part of planning practices within agencies
- Make certain that climate science is easily accessible to both the public and private sector
- Coordinate agency efforts in climate change responses with respect to overlapping jurisdictions, especially with regard to water resources, public health, oceans and coasts, and communities
- Support international adaptation efforts
- Collaborate and coordinate with local, state, and tribal managers

The Task Force identified guiding principles for decision makers to use in developing and implementing climate change adaptation. These include:

- ***Adopt Integrated Approaches:*** *Adaptation should be incorporated into core policies, planning, practices, and programs whenever possible.*
- ***Prioritize the Most Vulnerable:*** *Adaptation plans should prioritize helping people, places and infrastructure that are most vulnerable to climate impacts and be designed and implemented with meaningful involvement from all parts of society.*
- ***Use Best Available Science:*** *Adaptation should be grounded in the best available scientific understanding of climate change risks, impacts, and vulnerabilities.*
- ***Build Strong Partnerships:*** *Adaptation requires coordination across multiple sectors and scales and should build on the existing efforts and knowledge of a wide range of public and private stakeholders.*
- ***Apply Risk Management Methods and Tools:*** *Adaptation planning should incorporate risk management methods and tools to help identify, assess, and prioritize options to reduce vulnerability to potential environmental, social, and economic implications of climate change.*
- ***Apply Ecosystem-based Approaches:*** *Adaptation should, where relevant, take into account strategies to increase ecosystem resilience and protect critical ecosystem services on which humans depend to reduce vulnerability of human and natural systems to climate change.*
- ***Maximize Mutual Benefits:*** *Adaptation should, where possible, use strategies that complement or directly support other related climate or environmental initiatives, such as efforts to improve disaster preparedness, promote sustainable resource management, and reduce greenhouse gas emissions including the development of cost-effective technologies.*
- ***Continuously Evaluate Performance:*** *Adaptation plans should include measureable goals and performance metrics to continuously assess whether adaptive actions are achieving desired outcomes (Interagency Climate Change Adaptation Task Force 2010).*

Project Outcomes and Conclusions

The Task Force has provided a series of recommendations to advance a national climate change adaptation strategy for the United States. The Task Force released a second progress report, [*Federal Actions for a Climate Resilient Nation*](#), in 2011 that covers federal agency efforts to date that integrate adaptation into planning and policies, enhance community resilience to climate change, improve information sharing and coordination, and develop strategies to support natural resources sustainability in a changing climate. The next steps for the Task Force are to improve coordination between and among agencies and support the implementation of agency plans. Another progress report is expected in March 2014.

References

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Status

Information gathered from publications and other resources.

Citation

Gregg, R. M. (2010). *Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force* [Case study on a project of the White House Council on Environmental Quality]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Increase/Improve public awareness, education, and outreach efforts
 Policy: Create new or enhance existing policies or regulations

Developing a Climate Change Adaptation Plan for Forest and Water Resources in Alger County, Michigan

By: Rachel M. Gregg

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Project Summary/Overview

The Superior Watershed Partnership and Land Trust (SWP) partnered with the Model Forest Policy Program (MFPP) to develop an adaptation plan for Alger County, Michigan. SWP conducted vulnerability assessments of the county's forest and water resources and economy in a changing climate and developed adaptation actions for implementation. The [final plan](#) was released in December 2011.

Project Background

Alger County is located on the southern coastline of Lake Superior and contains the Munising Bay Watershed, which spans over 36,000 acres. The landscape contains 521,765 forested acres and 80 miles of coastline that provide habitat for black bears, whitetail deer, gray wolves, and the endangered Kirkland warbler, among others. The forests are transitional, straddling the southern boreal and northern hardwood forest types, and primarily managed by the U.S. Forest Service and the State of Michigan. These species, habitats, and water resources, and the economic sectors which depend upon them, will all be impacted by climate change. Over the last few years, the region has experienced more intense and extreme weather events, increased air and water temperatures, and extended droughts.

SWP is a non-profit organization based in Michigan that is engaged in conservation, protection, and public education initiatives in different communities, including Alger County. SWP participated in MFPP's [Climate Solutions University](#) in order to conduct vulnerability assessments of the natural resources and human communities of Alger County and develop a series of adaptation responses.

Project Implementation

The MFPP Climate Solutions University process includes four steps:

1. Local communities create stakeholder action teams.
2. Teams assess vulnerabilities and opportunities for action.
3. Teams develop actionable adaptation strategies.
4. Strategies are implemented and evaluated.

To create a plan for Alger County, SWP followed these steps, collecting data and consulting with

regional experts to assess risks and develop an adaptation plan. Multiple stakeholders were engaged throughout the project, including Pictured Rocks National Lakeshore, the U.S. Forest Service, and the Northern Institute of Applied Climate Science. Resources used included [Confronting Climate Change in the Great Lakes Region: Impacts on our Communities and Ecosystems](#) and the [Munising Bay Watershed Restoration Project and Water Quality Management Plan](#). The project team conducted assessments of the climate-related risks and vulnerabilities of Alger County's forests, water resources, and economy. The risks and vulnerabilities were assigned low, medium, and high rankings; these rankings incorporated both the likelihood of change and the probability that the change would cause harm.

Based on the outcomes of these assessments, the project team developed five adaptation goals; the goals included:

1. Maintain the ecological and economic viability of Alger County's forests.
2. Increase public awareness regarding climate change impacts.
3. Increase ecological integrity and function of county watersheds.
4. Improve public awareness of climate-related public health and safety issues.
5. Identify and take advantage of potential economic opportunities presented by climate change.

Each goal was assigned associated actions with which to implement these initiatives over the short (1-3 years), medium (3-10 years), and long (10-25 years) term; each action was also assigned a lead organization or agency to guide its implementation within a specified timeframe.

Project Outcomes and Conclusions

Projected outcomes of the Alger County adaptation plan include protection of threatened and endangered species and habitats, preservation of local economic opportunities, reduction in infrastructure and property damage, enhancement of climate-related education and awareness, and improvement of public water resources infrastructure, among others.

References

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www.mfpp.org/wp-content/uploads/2012/03/Alger-County_MI_Forest-and-Water_Climate-Adaptation-Plan_2011.pdf

Status

Information gathered from interview with project contact March 25, 2011, publications, and other resources.

Citation

Gregg, R. M. (2012). *Developing a Climate Change Adaptation Plan for Forest and Water Resources in Alger County, Michigan* [Case study on a project of the Superior Watershed Partnership and Land Trust]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Conduct training and planning exercises

Policy: Develop/implement adaptation plans

Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States²⁵⁸

By: Rachel M. Gregg

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Project Summary/Overview

The U.S. Fish and Wildlife Service, along with the National Oceanic and Atmospheric Administration, is creating a National Fish, Wildlife, and Plants Climate Adaptation Strategy to coordinate climate change responses in both the public and private sector. This strategy is one component of the Service's overall [Strategic Plan for Climate Change](#).

Project Background

In September 2009, Interior Secretary Ken Salazar signed Secretarial Order No. 3289, which required bureaus and offices under the Department of the Interior's purview to address mitigation and adaptation responses to climate change in their work. As a result, the U.S. Fish and Wildlife Service released [Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerating Climate Change](#) in September 2010, which lays out the Service's response strategies focused around **adaptation**, **mitigation**, and **engagement**. As part of the adaptation focal area, the Service is working with partners to create a National Fish, Wildlife, and Plants Climate Adaptation Strategy, which will act as a blueprint to guide adaptation action over the next 50–100 years.

Project Implementation

The strategy has been under development since June 2009 when the Service's National Conservation Training Center hosted a Conservation Leadership Forum to discuss the drafting of a national adaptation strategy. Attendees included representatives from federal and state natural resource agencies and non-governmental entities. A second forum was held in January 2010 to draft the strategy's Purpose and Guiding Principles.

The strategy's Purpose is to “provide a unified approach—reflecting shared principles and science-based practices—for reducing the impacts of climate change on fish, wildlife, plants, habitats, and associated ecological processes across geographic scales.” This unified approach will ideally be supported not only by the Department of the Interior's bureaus and offices, but also by other federal agencies such as the U.S. Forest Service, Natural Resource Conservation Service, National Oceanic and Atmospheric Administration, and the Army Corps of Engineers, in addition to state, tribal, and local governments, non-governmental organizations, and private sector entities.

The Guiding Principles of the strategy include:

²⁵⁸ Also available at <http://www.cakex.org/case-studies/2753>

1. Use a national, not federal, framework to guide adaptation action. This includes collaboration between federal, state, tribal, and local governments, non-governmental organizations, and the private sector.
2. Focus action on natural resources within the boundaries of the United States but do not exclude opportunities to consider global implications of climate change, especially with regards to Canada and Mexico.
3. Integrate science and management in order to effectively address ecological systems, ecosystem services and functions, species and habitat linkages, adaptive management approaches, monitoring, modeling, and assessments of risk and vulnerability.
4. Align the goals of the strategy as much as possible with those of the energy, forestry, water management, transportation, and agriculture sectors.
5. Engage in broad public outreach and education.
6. Identify science and policy needs, such as new technology, training opportunities, capacity building, and regulations.
7. Coordinate mitigation and adaptation approaches.
8. Acknowledge and respect the urgency needed to address global climate change.

Project Outcomes and Conclusions

The Service has hosted a series of listening sessions at various professional venues, meetings, and conferences to present the purpose and process of creating the strategy. A [draft](#) was released in early 2012 for review and public comment. The draft included seven goals to enhance the resilience of species and habitats in a changing climate; they included: conserving habitat, protecting ecosystem function, enhancing capacity for management, supporting adaptive management, increasing knowledge and understanding of climate change impacts, enhancing public awareness and action, and reducing non-climate stressors. Another draft of the strategy is in progress.

References

Public Draft of the Strategy (2012):

http://www.wildlifeadaptationstrategy.gov/pdf/public_review_draft.pdf

National Fish, Wildlife, and Plants Climate Adaptation Strategy:

<http://www.wildlifeadaptationstrategy.gov/>

Status

Information gathered from survey responses of project contact on February 15, 2010, personal communication, and other resources.

Citation

Gregg, R. M. (2010). *Developing a National Fish, Wildlife, and Plants Climate Adaptation Strategy for the United States* [Case study on a project of the U.S. Fish and Wildlife Service]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/Improve public awareness, education, and outreach efforts

Policy: Create new or enhance existing policies or regulations

Developing Ontario's Climate Change Adaptation Strategy and Action Plan

By: Rachel M. Gregg

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Project Summary/Overview

The Ontario Minister of the Environment created the Expert Panel on Climate Change Adaptation in 2007, which released a series of recommendations on adaptation actions that the province should take to prepare for climate change. [Climate Ready: Ontario's Adaptation Strategy and Action Plan 2011-2014](#) is based on the recommendations of the Expert Panel and contains five goals and 37 specific actions to guide the province in its climate change adaptation efforts.

Project Background

Ontario is Canada's most populated province or territory. Existing problems in the region include intense storms, floods, droughts, and heat waves. The province is already experiencing increased temperatures and more frequent and severe rainstorms; these events are expected to become more severe as the climate changes. In December 2007, the Minister of the Environment appointed eleven scientists and other experts to the Expert Panel on Climate Change Adaptation (Expert Panel) and charged them with identifying vulnerabilities and developing strategies focused on the environment, economy, human health, and infrastructure. In November 2009, the Expert Panel released [Adapting to Climate Change in Ontario](#), which included projected climate change impacts developed by the Canadian Climate Change Scenarios Network and recommended strategies for the province to implement. These strategies included:

1. Enhance government leadership and capacity to address climate change.
2. Incorporate and integrate climate change adaptation into existing government policies and programs.
3. Enhance community adaptation efforts by providing information, training, and tools.
4. Develop and disseminate risk management information and tools.
5. Increase collaboration and information sharing with other governments in Canada and around the world.
6. Establish a Climate Change Adaptation Directorate within the Ministry of the Environment to coordinate a provincial adaptation plan, enhance collaboration and integration, and improve knowledge sharing.
7. Identify and secure dedicated funding for climate change adaptation implementation.

Overall, the Expert Panel called for the Government of Ontario to, where possible, integrate climate change into all government policies, programs, and activities in order to achieve three objectives: maximum reduction of greenhouse gas emissions (mitigation), maximum reduction of vulnerability (adaptation), and the integration of these mitigation and adaptation measures in order to capitalize on potential benefits.

In 2011, the Government of Ontario released *Climate Ready: Ontario's Adaptation Strategy and Action Plan 2011-2014*, which was informed by the Expert Panel's recommendations. It focuses on what efforts can be made at the provincial level to address climate change impacts on infrastructure (e.g., roads, bridges, water supply, stormwater systems), agriculture, forestry, fisheries, shipping, tourism, public health, and ecosystems.

Project Implementation

Climate Ready outlines five goals and 37 actions to guide the province in its climate change adaptation efforts. The goals of the province's strategy are to:

1. Avoid loss and unsustainable investment while taking advantage of economic opportunities where possible.
2. Take reasonable and practical measures to increase ecosystem resilience to climate change.
3. Create and share risk management tools to support climate change adaptation efforts across the province.
4. Achieve a better understanding of future climate change impacts in the province.
5. Seek opportunities for collaboration and cooperation.

There are two cross-cutting actions across the five aforementioned goals; these are to mainstream the consideration of climate change adaptation in all provincial policies and programs and to establish a Climate Change Adaptation Directorate to coordinate and implement the strategy. Actions include promoting water conservation and efficiency, protecting infrastructure and water resources, conserving biodiversity and resilient ecosystems, increasing public awareness of climate change impacts, improving monitoring to include climate change, and leading the improvement of knowledge development and exchange, among others.

Project Outcomes and Conclusions

Project leads are in the midst of developing a performance management system to measure the successes of implemented actions. One of the primary lessons learned cited by staff is that, although it is difficult to create such an evaluation system, it would have been easier to develop one during the strategy development stage rather than after the plan was released. The Government of Ontario plans to release annual progress reports that document steps taken to achieve the goals and actions laid out in the strategy.

The Government of Ontario has also been active in establishing the Ontario Regional Adaptation Collaborative, integrating climate change into the Growth Plan for Northern Ontario, and developing and implementing WaterSense, a program that promotes water conservation and efficiency.

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Status

Information gathered from survey responses of project contact on June 26, 2012, personal communication, and other resources.

Citation

Gregg, R. M. (2012). *Developing Ontario's Climate Change Adaptation Strategy and Action Plan* [Case study on a project of the Ontario Ministry of the Environment]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools, Monitor climate change impacts and adaptation efficacy

Policy: Develop/implement adaptation plans, Create new or enhance existing policies or regulations

Enhancing Climate Change Education and Outreach for Wisconsin's Coastal Communities

By: Rachel M. Gregg

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Project Summary/Overview

Wisconsin Sea Grant (WSG) has a number of climate change-related education, outreach, and research initiatives underway. These projects are intended to support coastal community resilience and response to climate change impacts on built and natural systems.

Project Background

WSG is a University of Wisconsin-Madison-based statewide program that is focused on coastal research, education, and outreach. It is one of the 32 state programs funded by the National Oceanic and Atmospheric Administration's (NOAA) National Sea Grant College Program.

Wisconsin typically experiences a continental climate with cold winters and warm summers that supports viable industries, such as tourism and agriculture, and a variety of species and habitats. On its [website](#), WSG reviews some of the observed and projected climatic changes that are affecting or will affect the state, including:

Observed

- mean air temperatures have increased 4°F over the last 100 years, with approximately two-thirds of that increase occurring over the last 30 years
- lake ice cover has decreased over the past 150 years
- northward species range expansions
- earlier migration and blooming of some plants

Projected

- increased air temperatures
- drier summers
- changes in precipitation patterns
- more frequent droughts
- extreme weather events, including heat waves

WSG has two primary education and outreach projects focused on climate change. One is the Coastal Climate Wiki, which connects Sea Grant and NOAA staff with climate information. The other is the *Climate Change in the Great Lakes Region: Starting a Public Discussion* website, which hosts recordings, PowerPoint presentations, and summaries of eight seminars held in Wisconsin in 2007 on climate change.

Project Implementation

WSG created the Coastal Climate Wiki (www.coastalclimatewiki.org) in 2009 in order to serve as a collaborative site through which Sea Grant and NOAA staff involved in climate research, education, or outreach could share information. Registered users may add or modify entries with climate-related content. The site strives to maximize the “collective sum of the input from all participants.” This site is funded through a NOAA Sectoral Applications Research Program (SARP) grant.

The [Climate Change in the Great Lakes Region: Starting a Public Discussion website](#) hosts recordings of eight climate change seminars held in the state between March and September 2007. The initiative was supported by WSG, the Wisconsin Coastal Management Program, and NOAA. In order to extend the utility of the series and continue the discussion, all of the seminars are provided for free on the website; in addition, a summary report and DVD of the series are available in the WSG store. The seminars include presentations on climate change science, impacts to and vulnerabilities of built and natural environments, and adaptation strategies.

Project Outcomes and Conclusions

In addition to education and outreach, WSG is also engaged in research and technology development to support coastal community responses to climate change. Tools for evaluating economic impacts to coastal infrastructure and visualizing shoreline and lake level change are in development.

Status

Information gathered from publications and other resources.

Citation

Gregg, R. M. (2012). *Enhancing Climate Change Education and Outreach for Wisconsin's Coastal Communities* [Case study on a project of Wisconsin Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Fish, Fisheries, and Water Resources: Adapting to Ontario's Changing Climate

By: Rachel M. Gregg

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Project Summary/Overview

This integrated research project, which ran from 2007-2008, was initiated to better understand the implications of projected climate change impacts and adaptation responses on southern Ontario's fish, fisheries, and water resources. Climate change will have predominantly negative effects on species and habitats, and resulting economic effects are expected to be devastating to the region. In addition, changes in temperature and precipitation patterns will require alterations to water resources planning and management. This project included a cost-benefit analysis of how and when climate change adaptation measures might be applicable to protect the region's fish, fisheries industry, and water resources.

Project Background

This project's geographic focus was the southern portion of the province of Ontario, including Lake Ontario and Ontario's Mississippi River (a tributary of the Ottawa River) and its watershed, which has a drainage area of 3,750 km (Casselman et al. 2011). Climate-induced changes of concern for the region are increasing temperatures, changes in seasonality, altered water flows, reduced ice cover and thickness, altered precipitation patterns, and increasing extreme weather events, which may have both positive and negative effects on fish species, fish habitat, the fishing industry, and water resources (Casselman et al. 2011). This project was created to examine how, when, and where climate change adaptation measures could be implemented by identifying and assessing risk and vulnerability, evaluating adaptive capacity, and incorporating climate change into planning, policy, and management.

The project, jointly conducted by Queen's University and Mississippi Valley Conservation, ran from August 2007 to April 2008 and was supported by Natural Resources Canada's Climate Change Impacts and Adaptation Program. Four subprojects were created to inform how climate change will affect fish, fisheries, and water resources in the region:

1. *Fish and fisheries*: A review of how fish are adapting to changing climatic and environmental conditions and how that may affect the fisheries industry in the region (led by Dr. John M. Casselman).
2. *Stakeholder outreach and workshops*: A two-day workshop series – [*Weathering the Change: Adapting to Climate Change in the Mississippi Valley*](#) – to engage stakeholders in discussions about climate

change adaptation (led by Paul Egginton and Beth Lavender with assistance from Mississippi Valley Field Naturalists).

3. *Economics, consequences, and adapting to a changing climate*: A survey of fishermen, professionals, and businesses to analyze barriers and opportunities, observed climatic and environmental changes, and potential adaptation responses (led by Lucian Marcogliese).
4. *Water management responses to climate change*: A study to examine barriers and opportunities for regional water resources through hydrologic and hydraulic modeling and planning (led by Dr. Sobhalatha Kunjikutty, Paul Lehman, and Mississippi Valley Conservation).

Project Implementation

Numerous stakeholders were consulted throughout the entirety of the study, including scientists, engineers, decision makers, and resource managers from around Canada. These included the Mississippi Valley Field Naturalists, Lanark Stewardship Council, University of Guelph, Ontario Federation of Anglers and Hunters, Ontario Commercial Fish Producers, First Nations, Ontario Ministry Natural Resources, Department Fisheries and Oceans, Mississippi River Power Corporation, American Fisheries Society, and Canadian Aquatic Resources Section. The following section describes the four subprojects, methodologies used (where applicable), and relevant results.

Subproject 1: Fish and fisheries

Researchers examined if and how six fish species – bass, perch, pike, walleye, lake whitefish, and lake trout – are adapting to environmental change (e.g., altered spawning time) and climate-driven change (e.g., increased water and air temperatures and extremes in temperatures, altered precipitation), changes in community structure and abundance, and needed alterations in regulation, management, and assessment activities to integrate climate change impacts into the status quo. Fish and fisheries in the region have experienced other compounding stresses over the years, including overharvest, eutrophication, bioaccumulation of toxins, invasive species establishment, and changes in water flow velocity and timing. Project leads assembled existing data and conducted new analyses. Existing information used included long-term data sets that documented (1) altered thermal conditions (water and air) in Lake Ontario, the Bay of Quinte, and the Mississippi River and its watershed over the last three to seven decades; (2) trends in discharge and precipitation for Lake Ontario, the St. Lawrence River, and the Mississippi River and its watershed; and (3) patterns in water level fluctuations for Lake Ontario and the St. Lawrence River. Each of these data sets, in addition to literature reviews of changing thermal conditions and water dynamics in the region, were used to evaluate fish species' responses in terms of spawning, recruitment, and growth, related to changing thermal conditions and thresholds/groupings (e.g., warm water, cool water, and cold water). Researchers found evidence of different effects on species and habitat, including changes in temperature adaptation, mortality, recruitment, growth, abundance, interaction, range expansions and contractions, and community structure, which will affect resource users and managers.

Subproject 2: Stakeholder outreach and workshops – Weathering Climate Change

Two workshops were held on September 15th and September 22nd in 2007 and coordinated by the Mississippi Valley Conservation and Mississippi Valley Field Naturalists. Around 150 individuals from local governments, organizations, and the public participated. Presentations from experts from different disciplines (e.g., Intergovernmental Panel on Climate Change, Ontario Ministry of Natural Resources, Health Canada, etc.) formed the basis of the workshops, followed by facilitated breakout discussion groups to allow participants to discuss impacts, adaptation responses, and capacity and willingness to adapt. The workshop provided a means for project leads to engage the public on all

four components of the broader study in addition to allowing participants to provide insights to inform the other sub-projects. Presentations from the September workshops are available on the Mississippi Valley Conservation [website](#). A summary report *From Impacts Towards Adaptation: Mississippi Watershed in a Changing Climate*, authored by Paul Egginton and Beth Lavender, was released in 2008. The report includes key results from the participant discussions. For example, participants agreed that climate change is affecting the fisheries, habitats, and water resources in the region, and will have both positive and negative effects on agriculture, tourism, forestry, and fisheries, among other sectors. The participants unanimously adopted the Almonte Communiqué at the end of the workshops. The Communiqué states that:

Many important economic and social decisions are being made today on long-term projects and activities in our watershed based on the assumption that past climate data are a reliable guide to the future. This is no longer a good assumption. We believe that all levels of government are key players in this issue and must raise awareness and incorporate climate change into planning, decision making and leadership.

Subproject 3: Economics, consequences, and adapting to a changing climate

This subproject was conducted to (1) analyze economic consequences of climate change on fisheries resources in the region, (2) determine adaptive capacity of stakeholders, (3) identify economic and social values associated with fisheries resources in the region, and (4) create recommendations to support a sustainable fisheries industry. Researchers examined both regional conditions in Ontario and local conditions in the Mississippi River watershed. The subproject included a literature review of climate-induced changes on fisheries and resource users, and a survey of users and managers in northern and southern Ontario and the Mississippi Valley area to measure adaptive capacity, perceptions, and behavior in order to ascertain the economic consequences of climate change in the region. A copy of the survey may be found in [Appendix A3](#) of the final project report (Casselman et al. 2011). Researchers examined the effects of climate change on fish resources and fisheries in terms of environmental changes (e.g., temperature, precipitation, floods, etc.) and community changes (e.g., species, abundance), resource use, users' adaptability, and users' adaptive capacity. Approximately 307 of 749 distributed surveys were returned for a 41% response rate. Respondents indicated that their top four concerns are invasive species, habitat, water conditions, and climate change. Eighty-eight percent of respondents indicated that management and planning responses should be altered to incorporate climate change considerations; public education and regulations were the highest ranked of the supplied options, which also included lake stocking, increased enforcement, and research, among others. The survey also indicated that science should be the basis for any change in management action, while social and economic concerns were ranked much lower.

Subproject 4: Water management responses to climate change

This subproject examined the vulnerability of the Mississippi River Water Management Plan and its operations to climate change and provided recommendations to improve water management planning in the region to address climate change impacts. Water levels and flows are regulated by 23 dams and other control structures in the watershed (Casselman et al. 2011). The Mississippi River Water Management Plan was completed in 2006 although MVC noted that various trends not formally acknowledged in the plan, including climate change, could disrupt the outlined planning measures. This study was undertaken to downscale climate predictions of precipitation and temperature in the Coupled Global Climate Model (CGCM2) to the watershed level, quantify climate change impacts on the water budget, and simulate stream flows and water levels through modeling to inform future management decisions. Researchers used the following to generate

information about climate change influences on water resources in the region: CGCM2 model, [IPCC A2 scenario](#), Modified Thornthwaite Water Budget Model from Environment Canada, and [MIKE 11](#) (rainfall-runoff model).

Researchers identified several possible effects of a changing climate on water resources in the region along with potential adaptation responses; some examples included (Kunjikutty and Lehman 2008):

- The region may experience long-term, severe low flows that will require increased reservoir storage capacity, more stringent management and restriction of water use and consumption, and improvements to existing or design of new water control structures.
- Lower stream flows and water levels will likely decrease spawning capacity and habitat for walleye and pike in the region, which will require habitat protection and increased fish passage to avoid structural barriers.
- Lower stream flows and more intense precipitation events will reduce flushing capacity, increase runoff and nutrient loading, and cause low dissolved oxygen levels; managers will need to reduce point and non-point pollution and limit or eliminate removal, disruption, or alteration of vegetative buffers along streams and lakes.

Researchers recommended the incorporation of climate predictions into water management planning, increased communication and education to water resource users, increased reservoir storage capacity, and enhancement of integrated watershed management.

Project Outcomes and Conclusions

Researchers concluded that management of fish, fisheries, and water resources in southern Ontario requires more extensive monitoring and assessment, increased research and collaboration between multiple stakeholders, improved transfer of science and information among and between professionals and citizens, and strong adaptation measures. Different project staff provided several outreach presentations about this study to practitioners and the public; a special one-day symposium to present the results of this project was held in 2008 at the American Fisheries Society meeting in Ottawa. Several products were released as part of this project, including a final report (Casselmann et al. 2011), a summary report of the stakeholder workshops (Egginton and Lavender 2008), and a report on Subproject 4 (Kunjikutty and Lehman 2008).

References

Project Description: www.mvc.on.ca/conservation-education/climate-change/85-fish-fisheries-and-water-resources-adapting-to-ontarios-changing-climate

Casselmann, J.M., S. Kunjikutty, P. Lehman, L. Marcogliese, & J. Oblak. (2011). Report – Fish, Fisheries, and Water Resources: Adapting to Ontario’s Changing Climate. Report to Natural Resources Canada, Climate Change Impacts and Adaptation Directorate, Study A1367, Ottawa, Canada, in conjunction with Queen’s University and Mississippi Valley Conservation. March 2011.

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www.mvc.on.ca/images/stories/Climate%20Change/Water%20Mangement%20Response%20to%20Climate%20Change_Subproject%204_NRCAN.pdf

Status

Information gathered from publications and other resources.

Citation

Gregg, R. M. (2012). *Fish, Fisheries, and Water Resources: Adapting to Ontario's Changing Climate* [Case study on a project of Queen's University and Mississippi Valley Conservation]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change

Fostering a Climate-Informed Community Perspective in the Great Lakes: The Great Lakes Community Climate Program

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Project Summary/Overview

Freshwater Future developed the [Great Lakes Community Climate Program](#) to provide training and ongoing support to community groups and citizens to enable them to incorporate climate adaptation into their work. The program includes three components: training on climate adaptation for community-based groups, a resource toolkit, and a grants program. Freshwater Future partnered with EcoAdapt to offer climate symposia in cities in the Great Lakes region and to develop a [Great Lakes Climate Adaptation Toolkit](#) for community use. The symposia provide community groups with an understanding of how to approach their work from a climate-informed perspective. The toolkit acts as a training resource, as well as a way to extend the training experience for workshop participants and share climate adaptation information with other interested parties. The climate grants program offers funding to symposium participants and others interested in implementing projects in their communities.

Project Background

Freshwater Future is a nonprofit organization that provides financial, networking, and technical assistance to community groups and residents of the Great Lakes region focused on the conservation, protection, and restoration of lakes, wetlands, rivers, and shorelines. The organization developed the Great Lakes Community Climate Program to assist community groups and residents seeking to incorporate climate change into local decision making, activities, and projects. The program targets community-based groups in Michigan, Illinois, Indiana, Ohio, Pennsylvania, New York, Minnesota, Wisconsin, and Ontario.

The Great Lakes region is vulnerable to a number of climate threats, including changing precipitation patterns and extreme weather events, resulting in droughts, increased flooding hazards, property damage, and habitat degradation. The Great Lakes Community Climate Program, supported by the Kresge Foundation, aims to prepare community groups by providing capacity building opportunities, regionally tailored resources and tools, and a small grants program to kick start the implementation of adaptation efforts.

Project Implementation

Freshwater Future partnered with EcoAdapt, a nonprofit organization focused on climate change adaptation, to develop targeted resources and tools and provide adaptation training to help community groups prepare for a changing climate. Since 2010, EcoAdapt and Freshwater Future have hosted climate symposia in Detroit, Milwaukee, Toronto, and Buffalo. These workshops, based on EcoAdapt's [Awareness to Action](#) curriculum, have trained nearly 90 individuals from different community groups to begin incorporating climate change into their efforts to protect and restore freshwater resources. The symposia all followed a similar format by first orienting participants to climate change science basics and predicted regional impacts, before focusing on developing adaptation solutions applicable to local and regional scales. The goal of each workshop was to ensure that participants left having learned how to approach their work from climate-informed and prepared perspectives.

EcoAdapt and Freshwater Future also worked together to develop a regionally-targeted climate adaptation resource, the [Great Lakes Climate Adaptation Toolkit](#). The toolkit includes a [primer](#) on climate change and adaptation, four case studies on how other community groups in Michigan, Vermont, Montana, and British Columbia have begun incorporating climate change into their work, climate change communication guidance ([The 10 Do's and Don'ts of Discussing Climate Change](#)), [fact sheets](#) on specific Great Lakes climate impacts and approaches to addressing climate change, and [EcoAdapt's Climate Vulnerability Assessment Quick Guide](#).

Freshwater Future's climate grants program provides a funding resource to support on-the-ground climate change adaptation actions. Grant applicants have been encouraged to attend climate symposia and have received assistance in developing projects. Over the past two years, climate grants totaling \$207,450 have been awarded to 34 community projects in all eight of the U.S. Great Lakes states and the province of Ontario. Project examples include community rain garden projects to reduce local flooding and beautify neighborhoods, advocating for the inclusion of climate projections into mining permit conditions, and ensuring appropriate species are used in restoration projects so they will survive the impacts of climate change. More project examples are available at www.freshwaterfuture.org.

Project Outcomes and Conclusions

Through the climate symposia, the toolkit, and grants program, the Great Lakes Community Climate Program provides a number of resources and tools that are beneficial to grantees as well as the region as a whole. The resources created are available for dissemination in hard copy as well as on the Freshwater Future website. The partners are also conducting follow up surveys with workshop participants. Freshwater Future has received additional funding from the Kresge Foundation to continue this work, including sponsoring four more climate symposia with EcoAdapt between 2012 and 2014; the first of this new round of workshops was held in Duluth, Minnesota in October 2012.

Status

Information gathered from interviews with project contacts. Case study reviewed by project contacts.

Citation

Hitt, J. L. & Gregg, R. M. (2012). *Fostering a Climate-Informed Community Perspective in the Great Lakes: The Great Lakes Community Climate Program* [Case study on a project of Freshwater Future]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Increase/improve public awareness, education, and outreach efforts, Conduct training and planning exercises

Great Lakes Adaptation Assessment for Cities

By: Rachel M. Gregg

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Project Summary/Overview

The Great Lakes Adaptation Assessment for Cities (GLAA-C) project aims to advance climate change adaptation in the region. The project consists of a number of components, including collaborating with five cities in the region to either develop standalone adaptation plans or incorporate adaptation into existing plans and policies; creating online resource databases to support information sharing and exchange; researching climate and socioeconomic data and developing a series of case studies that demonstrate adaptation in action; designing a tool to support capacity building and assessment of the costs and benefits of action and inaction; and establishing a network of researchers, practitioners, and private sector representatives to support the project, provide recommendations, and facilitate cross-sector collaboration.

Project Background

Evidence of climate change is already visible in the Great Lakes region, characterized by shorter winters, increasing annual average temperatures, more frequent and extreme heat and precipitation events, and decreasing lake ice cover (Kling et al. 2003). Projections show that these effects are likely to continue and worsen with increasing variability in temperatures and weather patterns. These climatic changes and their associated secondary effects on the natural and built environments and human communities in the Great Lakes are the focus of the three-year, GLAA-C project. The overarching purpose of the project is to bring together researchers and practitioners to develop actionable climate change adaptation strategies, plans, and policies for cities in the Great Lakes region.

The GLAA-C project is led by six co-Principal Investigators from the University of Michigan, including Arun Agrawal (School of Natural Resources and Environment), Maria Carmen Lemos (School of Natural Resources and Environment), Elisabeth Gerber (Ford School of Public Policy), Larissa Larsen (Taubman College of Architecture and Urban Planning), Marie O'Neill (School of Public Health), and Ricky Rood (School of Engineering and School of Natural Resources and Environment). The project is supported by the Graham Environmental Sustainability Institute and funded with matching support from The Kresge Foundation; project staff also work with researchers from the Great Lakes Integrated Sciences and Assessments Center (GLISA).

Project Implementation

The GLAA-C project is entering the second year of a three-year project. Project staff are in the process of selecting five Great Lakes cities to collaborate with on adaptation planning; this may include developing standalone adaptation plans for the individual cities or assisting city officials to incorporate climate change adaptation strategies into existing policies and plans. Project staff, the co-PIs, and students have initiated the research and outreach needed to generate support for the project and advance its progress.

The co-PIs and their students have engaged in a number of research projects on climate impacts and gathered relevant socioeconomic data for the region, including:

- Collecting information on climate change impacts to the Great Lakes region, including heat waves, flooding, and lake level changes;
- Examining microclimates in the Great Lakes and creating a climate zone mapping strategy to support collaboration between cities as they plan for climate change;
- Identifying and applying eight variables of adaptive capacity – institutions, infrastructure, wealth and financial capital, social capital, political capital, human capital, information, and technology – to the cities of Ann Arbor and Grand Rapids, Michigan;
- Identifying how regulations and financial capacity affect urban adaptive capacity in four Ohio cities – Toledo, Dayton, Avon Lake, and Elryia; and
- Creating and conducting two surveys that focus on attitudes towards and challenges of climate change with both residents and elected and appointed municipal leaders.

All of this information will be used to support adaptation planning for five pilot cities in the region. In addition, the project team is developing adaptation databases, the Cities Impacts and Adaptation Tool (CIAT), and the Urban Council on Sustainability and Adaptation (UCSA).

Online adaptation resource databases. These databases, focused on networks, best practices, and the private sector, will facilitate information sharing and exchange. The first will include organizations that are currently working on urban sustainability and climate change issues in the region, as well as some groups that are working outside the region. The best practices database will include a library of resources, tools, strategies, and case studies of adaptation that are relevant to the Great Lakes. The private sector database will include members of the recreation, tourism, real estate, and construction industries who are engaged in incorporating adaptation strategies into their work. All three databases and relevant information will be incorporated into an interactive project website to be launched in 2013.

Cities Impacts and Adaptation Tool (CIAT). The form and function of the CIAT is still under discussion as the project team examines how to best serve cities. The original plan was to create a user-friendly tool that would incorporate the most up-to-date climate impact data for cities in the region, combine that data with relevant socioeconomic data, and develop a cost-benefit analysis to help cities identify options. The project team is currently conducting a survey of existing tools and an assessment of user needs in order to guide the direction of the tool's development.

Urban Council on Sustainability and Adaptation (UCSA). The UCSA is intended to act as an advisory committee to support the project and provide recommendations to support urban adaptation planning in the region. The goal of the UCSA is to form a multi-sector network of representatives who are working on adaptation initiatives to exchange ideas and facilitate the flow of

information between these sectors. The project team hopes to convene this group by early March 2013 and include public and private sector representatives.

Project Outcomes and Conclusions

The GLAA-C project team is planning to work closely with five cities in assessments of impacts, vulnerability, and adaptive capacity before developing strategies that may be incorporated into existing plans or policies or form the basis of standalone adaptation plans. To support this effort, the team is collecting climate impact and socioeconomic data, adaptation case studies, and tools and resources to enhance collaboration and information exchange. A workshop, *Forwarding Adaptation in the Great Lakes Region*, will be held November 7-9, 2012, hosted by the Graham Environmental Sustainability Institute and the Institute for Sustainable Communities. The meeting will bring together officials and stakeholders from cities in the region to assess risk and begin creatively thinking about ways to respond and adapt to climate change. After the conference, the project team will identify the five pilot cities based on their adaptive capacity.

References

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Status

Information gathered from interview with project contact on October 4, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Great Lakes Adaptation Assessment for Cities* [Case study on a project of the Graham Sustainability Institute at the University of Michigan]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Policy: Develop/implement adaptation plans

Infrastructure, Planning, and Development: Community planning (developing climate-smart communities)

Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Adaptation Strategies

By: Kirsten Feifel

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Project Summary/Overview

Coastal wetlands in the Great Lakes region will be impacted by climate change. Namely, changes in water level could have dire consequences for existing wetlands and dependent bird and fish communities. To examine the impacts climate change may cause to coastal wetlands, project staff assessed vulnerabilities and evaluated adaptation options.

Project Background

In 2002, the Department of Natural Resources Canada held an open call for proposals for the Climate Change Action Fund – Coastal Zone. Partners from the University of Waterloo, Canadian Wildlife Service, Environment Canada, and local, private environmental firms submitted a proposal to produce a report explaining the vulnerability of Great Lakes coastal wetland ecosystems to climate change and identifying and developing related management and policy adaptation strategies. Their objectives were to use GIS to analyze shoreline vulnerabilities of the Great Lakes, develop and apply bird and fish habitat suitability models to projected climate change scenarios, and evaluate feasibility and effectiveness of adaptation strategies. The proposal was successfully funded in 2003 to support a two-year project.

Project Implementation

The vulnerability assessment, adaptation strategies, and report were developed through the following activities:

- Use of historical aerial photographs to assess long-term changes in wetland plant community distribution. Photos from the Great Lakes region were analyzed for vegetation composition from the 1930s to 1999; periods of low water level occurred in the 1930s and 1960s, high water levels in the 1970s and 1980s. The photos were digitally analyzed using GIS software to examine the expansion and contraction of wetland vegetation communities in relation to Great Lakes water levels.
- Literature reviews, wetland surveys, habitat suitability models, and stakeholder input were used to assess the vulnerability of wetland bird and fish communities.
- Three Great Lakes coastal wetlands adaptation strategies were evaluated:
 - Wetland dyking – by comparing paired dyked and undyked coastal wetlands on Lake Erie and Lake Ontario;
 - Review of existing policy and land use planning processes to assess viability of adaptation via policy processes; and
 - Large-scale water level regulation to reduce impacts of changing water levels.

- Stakeholder consultations through meetings and interviews were conducted to aid in project scoping and design, to obtain feedback on key vulnerabilities and thresholds, and to obtain feedback on climate change adaptation scenario evaluations.

Vulnerability indices were developed for coastal wetland plant species. Plants were categorized into low, moderate and high risk groups based upon their drought-tolerances and modes of colonization. Highly vulnerable plant species included wild rice and Hill's pondweed; least vulnerable were several invasive species such as purple loosestrife and common reed. Models were developed based upon GIS analyses of historical photos to link vegetation community types with average water depths. This was then used to assess potential climate-related impacts.

Bird models were based upon available survey data of breeding bird abundance in different habitats. Regression equations were developed using bird abundance relative to wetland habitat availability. Fish models were also developed based on life stage preferences to estimate habitat suitability and thermal preferences. A Habitat Alteration Assessment Tool was used to identify suitable fish habitats based upon depth, vegetation type, and substrate type for six fish guilds in three life stages. Assessments were conducted using four climate change scenarios; two extremes representing the wettest and warmest conditions and driest and warm conditions and then two moderate wet/dry warm conditions.

Project Outcomes and Conclusions

Results from the vulnerability assessment indicated that lower water levels will impact the distribution and abundance of wetland vegetation and bird and fish communities. Wetlands within lacustrine embayments were most resilient to the impacts of a lowered water table. The largest impacts were seen in riverine wetlands. Both the bird and fish vulnerability models provided inconsistent results and highlighted the need for large-scale assessments to determine higher trophic level responses to climate change.

The adaptation strategy that was ranked as the highest priority was developing and implementing effective land use planning and policies to protect the natural processes that create wetlands. The final report, released in 2006, concluded that research efforts should be focused on verifying plant and animal vulnerabilities to climate change and collecting high quality hydrological data (Mortsch et al. 2006).

References

Great Lakes Coastal Wetland Communities website

www.environment.uwaterloo.ca/research/aird/wetlands/index.htm

Mortsch, L., J. Ingram, A. Hebb, and S. Doka (eds.). 2006. *Great Lakes Coastal Wetland Communities: Vulnerability to Climate Change and Response to 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. 251 pp.+ appendices. http://environment.uwaterloo.ca/research/aird/aird_pub/Great_Lakes_Coastal_Wetlands_Report_2006.pdf

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Adaptation Strategies* [Case study on a project of Environment Canada]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Conduct training and planning exercises

Natural Resource Management and Conservation: Enhance connectivity and areas under protection

Great Lakes Observing System

By: Rachel M. Gregg

Contact Information

Great Lakes Observing System
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Project Summary/Overview

The [Great Lakes Observing System \(GLOS\)](#) was established to support a more comprehensive and coordinated approach to data and information access in the region. GLOS connects data users with data providers in order to improve and support decision making. GLOS has four primary focus areas – Ecosystem Health, Public Health and Water Security, Maritime Operations, and Climate Change and Natural Hazards – and provides data and tools to users to support decision making in the Great Lakes.

Project Background

GLOS is a non-profit organization that supports decision making by connecting data users with data providers. Their vision is to support an “integrated, bi-national observing system that provides products and services to decision-makers, resource managers, and other data users with input from members and partners, to foster understanding and inform decision making related to the Great Lakes and St. Lawrence River System.” GLOS was founded in 2003 and supported by the National Oceanic and Atmospheric Administration’s (NOAA) Coastal Services Center and Great Lakes Commission; in 2008, GLOS was formally recognized as a 501(c)(3) nonprofit.

GLOS is the only freshwater regional association out of the 11 that are part of the [U.S. Integrated Ocean Observing System \(IOOS\)](#), led by NOAA. To fulfill its mission, GLOS helps coordinate and manage regional data and information needs, provides up-to-date observations and models, and solicits stakeholder input to support programmatic planning and evaluation.

The four primary focus areas of the GLOS are Ecosystem Health, Public Health and Water Security, Maritime Operations, and Climate Change and Natural Hazards. In the latter focal area, GLOS is prioritizing the development of adaptation strategies by providing monitoring and modeling support to Great Lakes decision makers for flooding, non-point source pollution, stormwater management, shoreline management, and water availability issues.

Project Implementation

GLOS released [A Blueprint for Great Lakes Decision Making 2011-2015](#) to guide activities over a five-year period; the document was developed as a complement to NOAA’s [Next Generation Strategic Plan](#), the IOOS Strategic Plan, and the [Great Lakes Restoration Initiative Action Plan](#). The document lays out goals and objectives to achieve GLOS’ overall mission as well as to address the four focus areas.

The Climate Change and Natural Hazards focus area is the only one to specifically address adaptation; the specific goal is to “improve understanding and the development of adaptation strategies related to the impacts of climate change on Great Lakes communities and allow more

effective mitigation of the effects of natural hazards” (GLOS 2011). In order to do this, GLOS is participating in the International Upper Great Lakes Study’s Adaptive Management Working Group to identify the risks of lake level change and establish a robust, long-term monitoring program for decision support. In addition, other projects, focused on providing observational and modeling support for the management of flooding and stormwater, shorelines, and water resources, specifically water supply shortages, are being funded by GLOS.

Project Outcomes and Conclusions

GLOS provides data and tools through various portals on its website. Current portals include the [Observations Explorer](#), where users can view real-time and historic data from stations and buoys around the Great Lakes; the [Huron to Erie Connecting Waterways Forecasting System](#), which provides water level and current forecasts for the St. Clair River, Lake St. Clair, and Detroit River; the [Point Query Tool](#), where users can gain access to Great Lakes Coastal Forecasting System data; and the [Great Lakes Model Inventory](#), which allows users to share and find tools, people, and organizations engaged in ecosystem health, public health, marine operations, and climate change adaptation.

References

Great Lakes Observing System (GLOS). (2011). A Blueprint for Great Lakes Decision Making 2011-2015.
<http://glos.us/sites/default/files/documents/Blueprint%20for%20GL%20Decision%20Making.pdf>
 GLOS Factsheet:
www.glos.us/sites/default/files/documents/What%20is%20GLOS%20Factsheet_0.pdf

Status

Information gathered from publications and other resources.

Citation

Gregg, R. M. (2012). *Great Lakes Observing System* [Case study on a project of the Great Lakes Observing System]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Create/enhance resources and tools, Increase/improve public awareness, education, and outreach efforts

Great Lakes Restoration Initiative

By: Rachel M. Gregg

Contact Information

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

Project Summary/Overview

The Great Lakes Restoration Initiative (GLRI) was created to coordinate restoration efforts in the region. The GLRI released an [Action Plan](#) in 2010, which builds upon the 2005 Great Lakes Region Collaboration Strategy, and is the basis upon which Great Lakes restoration will be planned and budgeted at the federal level. Climate change has been recognized as a major threat to the region and, to the extent possible, will be addressed through different focus areas, including toxics, invasives, pollution, restoration, education, communication, and monitoring.

Project Background

The Great Lakes contain approximately 20% of the world's freshwater surface supply and 95% of the surface freshwater in the United States (GLRI 2010). Issues in the region include habitat and species loss from development, water flow alteration, and habitat fragmentation; degraded air and water quality from nonpoint source pollution, legacy contaminants in sediments, and riverine and atmospheric deposition; invasive species establishment; and information gaps that hinder decision making (GLRI 2010); climate change is expected to compound these problems.

In February 2009, President Barack Obama proposed a \$475 million budget to create the GLRI; the Great Lakes Interagency Task Force is responsible for implementing the initiative. The Task Force is chaired by the Environmental Protection Agency and supported by the Council on Environmental Quality, Department of Agriculture (Animal and Plant Health Inspection Service, Forest Service, Natural Resources Conservation Science), Department of Commerce (National Oceanic and Atmospheric Administration), Department of Defense (Army Corps of Engineers), Department of Health and Human Services (Agency for Toxic Substances and Disease Registry), Department of Homeland Security (U.S. Coast Guard), Department of Housing and Urban Development, Department of the Interior (Bureau of Indian Affairs, Fish and Wildlife Service, Geological Survey, National Park Service), Department of State, and Department of Transportation (Federal Highway Administration, Maritime Administration). The Task Force created the GLRI Action Plan to guide restoration activities in the region from 2010-2014. The Action Plan defines restoration as (GLRI 2010):

the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. For purposes of this Initiative, restoration includes ecosystem protection, enhancement, rehabilitation and remediation. A restored ecosystem is resilient; its chemical, physical, and biological functions and processes provide the requisite conditions for life. A restored ecosystem contains sustainable populations of native plant and animal species and their habitats. Potential threats or further damage have been eliminated or reduced as much as possible and the restored ecosystem is able to withstand future threats.

Project Implementation

In 2005, 1500 stakeholders developed the Great Lakes Regional Collaboration Strategy, which identified and recommended solutions for eight priority issues – Aquatic Invasive Species,

Habitat/Species, Coastal Health, Areas of Concern (AOCs)/Sediments, Nonpoint Source, Toxic Pollutants, Indicators and Information, and Sustainable Development. The GLRI Action Plan took these eight issues and condensed them down to five priorities:

1. Toxic Substances and Areas of Concern
2. Invasive Species
3. Nearshore Health and Nonpoint Source Pollution
4. Habitat and Wildlife Protection and Restoration
5. Accountability, Education, Monitoring, Evaluation, Communication and Partnerships

Each focus area is further defined with goals, objectives, ecological targets, and specific actions. The GLRI Action Plan is implemented and evaluated by the Great Lakes Interagency Task Force. Those who receive GLRI funding are required to submit reports that measure and evaluate progress on the goals of individual projects as well as the overall goals of the GLRI. All projects may be reviewed by the public through the [Great Lakes Accountability System](#) (GLAS); the database allows users to search by focus area, funding recipients, and geography (states, Areas of Concern, or watersheds).

Project Outcomes and Conclusions

Through the GLRI, the Environmental Protection Agency administers funding on its own and in collaboration with other federal agencies to support restoration efforts in the region. Money is awarded for both federal projects and other projects by non-federal groups that support the goals outlined in the Action Plan. Although climate change is not listed as one of the primary focus areas, the Action Plan states that restoration activities that address the outlined priorities will “increase the resiliency of the ecosystem [and therefore] help the Great Lakes adapt to climate change” (GLRI 2010).

As part of the September 2010 workshop [Climate Change in the Great Lakes: Advancing the Regional Discussion](#), participant comments were solicited on the GLRI and other federal funding programs. Participants recommended that the GLRI incorporate climate change into request for proposals, enhance collaboration and knowledge exchange, integrate adaptation into urban sustainability efforts, and conduct all efforts with both short- and long-term goals in mind (Hinderer et al. 2010). In the 2012 request for proposals, the Environmental Protection Agency listed increasing climate change resilience in Great Lakes communities as one of the primary funding categories, specifically to fund vulnerability assessments and the development and implementation of adaptation plans.

References

Great Lakes Restoration Initiative Action Plan: FY2010 – FY2014. 2010.

http://glri.us/pdfs/glri_actionplan.pdf

Hinderer, J., C. Haven, & M. Koslow. (2010). Climate Change in the Great Lakes: Advancing the Regional Discussion.

www.iceleiusa.org/library/documents/ClimateChangeintheGreat%LakesReport.pdf

Status

Information gathered from publications and other resources.

Citation

Gregg, R. M. (2012). *Great Lakes Restoration Initiative* [Case study on a project of the Great Lakes Restoration Initiative]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions

Natural Resource Management and Conservation: Incorporate climate-smart guidelines into restoration, Reduce local climate or related change, Reduce non-climate stressors likely to interact with climate change

Helping Michigan's Farmers Understand and Adapt to the Impacts of Climate Change

By: Jessi Kershner

Contact Information

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Project Summary/Overview

Climate change impacts in the Midwest include warmer temperatures, more precipitation, and greater weather variability. These impacts are likely to affect Michigan's field crops in both positive and negative ways, although understanding exactly how these changes will manifest remains uncertain. In late 2010, researchers at Michigan State University Extension and the Kellogg Biological Station initiated a project to begin engaging agricultural producers, scientists, and decision makers in discussions about climate change and agriculture. The purpose of this project was to increase understanding among the agricultural community about the ways in which climate change is likely to impact agriculture, and explore what information and resources farmers need in order to be able to adapt to potential changes.

Project Background

Climate change impacts in the Midwestern U.S. include warmer temperatures, more precipitation in winter and spring, increased summer evaporation, greater weather variability, shifts in diseases and pests, and a longer growing season. Many of the projected impacts are likely to affect Michigan's field crop agriculture in both positive and negative ways. For example, a longer growing season and more precipitation can improve crop growth but may lead to more plant diseases and pests (Doll and Baranski 2011). Understanding all the ways in which future climate changes may impact crop agriculture is extraordinarily complex, and unlikely to be fully explained in the coming years. Regardless, agriculture will need to be better prepared for changing conditions and have adaptive measures at the ready.

To help Michigan's field crop farmers adapt to and mitigate changing climate conditions, researchers at Michigan State University (MSU) Extension and the W.K. Kellogg Biological Station (KBS) teamed up together on a project to find ways of engaging the agricultural producer, scientist, and decision-maker communities in discussions about climate change and agriculture. The project's primary audiences were MSU Extension educators and agricultural professionals who may incorporate climate information into their programming to reach agricultural producers across the state. Funding for the project was provided by Project GREEN (Generating Research and Extension to meet Economic and Environmental Needs), Michigan's plant agriculture initiative at MSU, and an U.S. EPA Environmental Education grant. Additional support for this research was provided by the NSF Long-Term Ecological Research Program at the Kellogg Biological Station and by Michigan State University AgBioResearch.

Project Implementation

Researchers at KBS worked with MSU Extension educators and the Michigan Farm Bureau to set up 4 focus group discussions with Michigan field crop farmers from December 2010 through January 2011; over 17 counties were represented through the focus groups. The first round of focus groups discussed the availability of climate change information for farmers, and included questions such as: (1) where do you hear about climate change; (2) what are your current sources of climate-related information; (3) if you wanted more climate information, where would you go to get it; (4) what topics related to climate change are important to understand; and (5) do you see MSU Extension playing a role in disseminating climate change information and if so, how? Group facilitators also talked with farmers about the ways in which they are already adapting to climate change. For example, some farmers expressed that they are now using larger equipment to complete field tasks because the window of time to get things done is shifting.

A second round of focus groups was held in January 2012. This round was focused more on climate adaptation and included topics such as: (1) perceptions of climate change and if it has or will lead to adaptation; (2) perceptions of climate change adaptation and adaptation in general; and (3) what resources farmers would need to be able to adapt. Two overarching research questions for this round included: (1) how do policymakers and scientists view adaptation compared with how farmers view adaptation and (2) what differentiates the adaptation that farmers always do (or have done) from climate change adaptation?

Project Outcomes and Conclusions

To improve climate education in the agricultural community, the project team produced a series of fact sheets including climate basics; greenhouse gas basics; frequently asked questions about climate change; and how agriculture contributes to climate change, how it may be impacted, and what it can do about it. Fact sheets were produced in both English and Spanish. They are available for download at <http://lter.kbs.msu.edu/get-involved/educational-resources/>.

Out of this work, MSU Extension also formed the Climate Variability and Change Action Team (CVCAT) to help the Michigan communities prepare for climate change. Currently the group has members from every program in Extension. It has hosted several [webinars](#) and an in-service training on climate, water, and agriculture for Extension. MSU Extension has also started to change their programming and explore new ways to address the needs that came up in focus group discussions with farmers.

Two peer-reviewed articles are expected to be published based on this work – one a case study on training MSU Extension educators to help agriculture prepare for climate change and one on the results from the climate change adaptation focus groups. The first article, *Using stakeholder needs and deliberative dialogue to inform climate change outreach efforts*, is currently in press in the Journal of Extension. Project team leads have also hosted several trainings including one on climate change communication and helping communities understand why they would want to address climate change, and another linking climate scientists and journalists (led by the MSU Knight School of Journalism and the Society for Environmental Journalists and funded by an NSF climate change education grant). No formal next steps are anticipated for the project, although the team hopes to find a way to continue long-term dialogue between farmers and scientists. To accomplish this, they anticipate the need for funding a coordinator who can dedicate time to long-term planning and engagement.

Factors that contributed to the project's success:

- To get stakeholder buy-in early on, the project team initially worked with Extension educators and members of the Michigan Farm Bureau who then helped to recruit others to participate in the focus group discussions about climate change.
- The project team was open to participation from all program areas in MSU Extension. This has strengthened the activities of the Climate Variability and Change Action Team.

References

Doll, J.E. and M. Baranski. (2011). *Field Crop Agriculture and Climate Change*. Michigan State University Extension, Climate Change and Agriculture Fact Sheet Series E3149.

<http://lter.kbs.msu.edu/wp-content/uploads/2012/06/E3149-Climate-Change-Fact-Sheet.pdf>

Project GREEN:

www.green.msu.edu/green/projects/preparing_extension_educators_to_help_state_field_crop_industry_address_rea

Status

Information gathered from interview with project contact on March 29, 2012. Case study reviewed by project contact.

Citation

Kershner, J. M. (2012). *Helping Michigan's Farmers Understand and Adapt to the Impacts of Climate Change* [Case study on a project of Michigan State University Extension and Kellogg Biological Station – Michigan]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Create/enhance resources and tools, Increase/improve public awareness, education, and outreach efforts

*Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA)
using GPS Telemetry²⁵⁹*

By: Jessica Hitt

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Project Summary/Overview

The National Park Service (NPS), along with the University of Minnesota's Natural Resources Research Institute (NRRI) and the U.S. Geological Survey (USGS), are undertaking a cooperative study to track a small number of moose in Voyageurs National Park, Minnesota using global positioning system (GPS) collars. The collars will provide location data at 15 minute intervals while also recording temperature and activity data every minute. The collar data collected will allow researchers to test hypotheses about moose movement in relation to changes in temperature and weather. Results will give managers a better idea of how moose will respond to warmer temperatures as a result of climate change and allow them to plan for suitable refugia.

Project Background

In January 2009, an aerial survey of Voyageurs National Park commenced a long-term study funded by the NPS and USGS. The survey was the first completed since 1992 and roughly 45 moose were sighted. The survey is the first phase in a project aimed at gathering information on how climate change will impact moose in Voyageurs National Park. The study will test managers' hypotheses on how moose will respond to climate change and will gather data to document changes in moose populations and distributions since the 1992 survey.

The study was motivated by the high death rates of moose populations in other areas in Minnesota and a general concern about the impacts of climate change on the species in the southern range of its habitat. Some researchers believe the mortality rates are due to chronic heat stress that moose populations are experiencing because of rising winter and summer temperatures. The next phases of the project will use GPS radio collars to track moose movements and temperature data. The project will rely on monitoring to track the impacts that climate change and temperature changes have on moose populations and distribution. The results of these monitoring efforts will be used to identify forest types that moose use as thermal refugia during periods of elevated temperatures and incorporate those habitats into future restoration and management approaches.

Project Implementation

A team from NPS and other cooperators captured 12 moose (ten females and two males) in February 2010 and attached GPS collars to them. Each collar is outfitted with a GPS receiver that records location data every 15 minutes as well as an external temperature sensor that records

²⁵⁹ Also available at <http://www.cakex.org/case-studies/2389>

weather conditions and activity every minute. The collar can also signal when a moose has died to allow researchers to retrieve the animal quickly and determine cause of death, if possible. Collars can store data for 14 months. Moose were recaptured in February 2011 to download data from the collars and replace batteries; an additional six moose were captured and fitted with similar GPS collars in March 2012. The study has gathered data from more than 100,000 locations and will conclude in early 2013.

This differs from other moose telemetry studies occurring in Minnesota in recent years. In addition to being the first project to use GPS collars, the collars used in the Voyageurs' project include temperature sensors that measure ambient temperature and activity sensors that monitor whether a moose is moving or stationary. This will allow researchers to look at location data as it relates to temperature and activity of moose populations. A similar study was initiated in Grand Portage Indian Reservation, Minnesota, in 2010 and other locations in Minnesota and Ontario in 2011.

Project Outcomes and Conclusions

Data gathered from the collared moose will be used to test researchers' hypotheses on how moose habitat use and distribution will be impacted by increased temperatures. The findings will be used to improve habitat management for moose populations in Voyageurs National Park as well as target future research needs for moose in the area.

References

Voyageurs National Park to Collar Moose: <http://www.nps.gov/voya/parknews/voyageurs-national-park-to-collar-moose.htm>

Voyageurs National Park Moose Project: <http://www.nrri.umn.edu/moose/research/voyageurs.html>

Status

Information gathered from interview with project contact and other resources. Case study reviewed by project contact.

Citation

Hitt, J. L. (2010). *Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA) Using GPS Telemetry* [Case study on a project of Voyageurs National Park]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Monitor climate change impacts and adaptation efficacy

Natural Resource Management and Conservation: Enhance connectivity and areas under protection

Incorporating Climate Change into TMDL Decisions for Lake Champlain

By: Jessi Kershner

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Project Summary/Overview

Lake Champlain, located between the Green Mountains of Vermont and the Adirondack Mountains of New York, has historically suffered from problematic blue-green algae blooms that are dangerous to the health of humans, fish, and wildlife. The blooms are primarily caused by excess non-point source pollution entering the lake, which is likely to be exacerbated by climate impacts such as changes in precipitation and flashier storms. In light of this threat, the Conservation Law Foundation began investigating existing regulatory policies and the ways in which they could be revised to limit algal blooms under future climate change. This case study is also part of a [Climate Adaptation Toolkit](#), developed in partnership between EcoAdapt and Freshwater Future.²⁶⁰

Project Background

Lake Champlain has a pollution problem. The lake – situated between the Green Mountains of Vermont and the Adirondack Mountains of New York – suffers from problematic blue-green algae blooms (also known as “pond scum”). When environmental conditions are just right – the algae prefer warm, slow-moving water enriched with nutrients like phosphorous or nitrogen – blue-green algae can grow fast, creating scum layers or floating mats which, in addition to being unsightly, are dangerous to human, fish, and wildlife health. In Lake Champlain, the primary culprit causing these massive blooms is excess phosphorous.

Pollutants such as phosphorous enter a lake from two types of sources: point sources – clearly identifiable sources like a pipe or ditch that flows directly into the lake – or non-point sources, which are more diffuse. With non-point source pollution, pollutants may be deposited into lakes and water bodies directly by wind or rain, or they may be picked up by rainfall or snowmelt moving over the ground and carried into lakes and water bodies that way. In Lake Champlain, excess phosphorous mainly comes from non-point sources like agricultural and urban runoff, although sewage treatment plants also contribute.

People have been combating the Lake Champlain pollution problem for a number of years. In 2002, the states of Vermont and New York jointly developed a Total Maximum Daily Load (TMDL) for the lake, which was approved by the U.S. Environmental Protection Agency (EPA). A TMDL describes the total amount of a pollutant – in this case, phosphorous – that can be put into the lake but is still considered safe for people, fish, birds, and other wildlife. Both point and non-point

²⁶⁰ <http://www.freshwaterfuture.org/resources/climate/climate-adaptation-toolkit.html>

source pollutant amounts are used to calculate the TMDL, but while point source pollution amounts are relatively easy to determine, non-point source pollution is not.

In order to calculate the amount of non-point source pollutants, the EPA uses watershed models based on how much precipitation (rain and snow) falls in a single year. In the case of Lake Champlain, 1991 was chosen as the representative year and used to determine the total non-point source pollutant amount. However, since 1991 there has been a trend toward wetter years overall and more intense storms that produce higher flows. More precipitation and higher flows mean more polluted runoff, whether it's through erosion from a farm field with layers of fertilizer or from a construction site. By using precipitation numbers that were already 10 years old and ignoring long-term trends in precipitation and storminess, the 2002 TMDL was likely to grossly underestimate the amount of non-point source pollution. In addition, future climate projections including warmer temperatures, changes in precipitation, and increased frequency and intensity of storms would likely exacerbate existing conditions. Based on these concerns, staff at the Conservation Law Foundation (CLF) began reviewing the literature to find support for appealing the TMDL.

Project Implementation

In reviewing the literature, the CLF found a 2008 EPA publication looking at climate change and the water cycle, and ways the EPA would need to adjust its regulatory program (including the TMDL) to account for these changes. In particular, the paper talked about the impact of global warming on precipitation and how it was likely to make preexisting problems, such as non-point source pollution, worse. However, in order to repeal a decision that has already been made, the CLF needed to find evidence demonstrating that the EPA knew or should have known about climate change impacts back in 2002. In their researching, the CLF found that the U.S. government had been funding climate change research since at least the 1980s, including an interagency work group that had been developing different scenarios of climate impacts on water and other important resources.

After finding enough support for repealing the Lake Champlain TMDL, the CLF filed a lawsuit against the EPA in 2008. In January 2011, the EPA rescinded their approval of the Vermont portion of the Lake Champlain TMDL, due in part to the predicted effects of climate change on lake water quality.

Project Outcomes and Conclusions

As a result of this lawsuit, the EPA has initiated a nationwide study of the relationship between potential climatic changes and increasing non-point source pollution. They plan to look at how different pollution control techniques (e.g., conventional practices vs. green infrastructure) work under changing climatic conditions. Lake Champlain will be included in the nationwide study and the results will be factored into the new TMDL.

The Vermont Agency of Natural Resources and the EPA are also working on an extensive community outreach campaign to figure out what's happening in terms of actual on-the-ground pollution control, what ideas people have to do more, and discuss what's working for folks and what's not. The CLF and others hope the result of all this discussion and research will be a new TMDL that is truly comprehensive – one that gets the region on a path toward controlling pollution and a clean and healthy Lake Champlain far into the future.

Status

Information gathered from interview with project contact on October 4, 2011. Case study reviewed by project contact.

Citation

Kershner, J. M. (2012). *Incorporating Climate Change into TMDL Decisions for Lake Champlain* [Case study on a project of the Conservation Law Foundation]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Policy: Create new or enhance existing policies or regulations

Integrating Climate Change into Municipal Watershed Management in Ontario

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Project Summary/Overview

The Toronto and Region Conservation Authority (TRCA) is engaged in multiple climate change projects focused on integrating adaptation into long-term planning for natural and built systems. This includes developing resources and networks to support knowledge exchange between practitioners and conducting assessments to evaluate the challenges presented by global climate change.

Project Background

Observed climatic changes in Ontario include increases in temperatures and altered precipitation patterns; these changes are expected to continue and increase in frequency and intensity over time. These changes will have cascading effects on water resources in the province, including an increased need for drinking water source protection, water allocation planning, water quality monitoring, and improved management of stormwater systems, dams, and reservoirs. TRCA has worked on watershed management and sustainability issues in Ontario since the 1950s and has integrated climate change adaptation and mitigation measures into its efforts. Example adaptation initiatives include the Mainstream Project, the Climate Consortium for Research Action and Integration, and a vulnerability assessment of some of the public water resources infrastructure under its purview.

Project Implementation

Mainstream: The National Water Adaptation to Climate Change Project

The Mainstream project, funded through the Ontario Regional Adaptation Collaborative, was created to collect and present information on climate change and water resource management in Canada. Partners include TRCA, the Canadian Water Resources Association, the Canadian Foundation for Climate and Atmospheric Sciences, the Institute for Catastrophic Loss Reduction, Conservation Ontario, the Ministries of Natural Resources and Environment, York University, ESSA Technologies, North Arrow Research, EBNFLO Environmental, and AquaResource/Matrix Solutions. Activities include:

- Providing a Mainstream Forum for networking and knowledge exchange on climate adaptation.
- Creating a compendium or database of climate change adaptation resources and tools related to extreme storms and flooding events;
- Writing a status report on adaptation in water resources management in Canada; and

The Mainstream Forum was held March 22-23, 2012 in Toronto. The stated objectives of the forum were to:

- *Provide learning opportunities for new ways of thinking about water adaptation;*
- *Reflect upon the current state of practice and share knowledge on water adaptation projects;*
- *Showcase a diverse range of projects led by Forum participants;*
- *Stimulate discussion to identify:*
 - *Water adaptation knowledge needs of practitioners (e.g., engineers, scientists, policy analysts, project coordinators, planners, and educators);*
 - *Opportunities for dissemination of knowledge and collaboration towards the mainstreaming of adaptation.*
- *Contribute to:*
 - *A national compendium of knowledge on water resource adaptation to be used by practitioners; [and]*
 - *A briefing document on the state of and opportunities for advancing water adaptation across Canada. (Forum Results Report 2012).*

The compendium is geared toward water resources practitioners from municipalities, watershed organizations, private sector groups, advocacy groups, and provincial/territorial agencies in Canada and around the world. Its purpose is to provide information and training on climate change adaptation as it relates to water resources. The website was launched in June 2012 at <http://waterandclimate.ca>.

Climate Consortium for Research Action and Integration (CC-RAI)

The CC-RAI is a partnership between the TRCA and York University to coordinate research and provide resources and tools to practitioners in Ontario and the Great Lakes region.

Public Infrastructure Vulnerability Studies

The TRCA and Engineers Canada conducted a vulnerability assessment of two dams that TRCA operates using the protocol developed by the Public Infrastructure Engineering Vulnerability Committee (PIEVC). The TRCA applied this protocol to determine the ways in which the dams might fail due to climatic changes, including an engineering analysis of infrastructure capacity to handle increased water flows in a changing climate. In addition to the PIEVC protocol, the partners applied climate models, a climate trend analysis, a literature review, and expert opinion.

Project Outcomes and Conclusions

TRCA has engaged in a number of adaptation projects, including the three highlighted here. Their philosophy is to integrate climate change into the day-to-day practices of their partners and associated stakeholders. Through the Mainstream Project, TRCA and its partners have created a national water resources database of adaptation tools that supports open information exchange between practitioners.

Status

Information gathered from interview with project contact on April 2, 2012 and other resources.

Citation

Gregg, R. M. (2012). *Integrating Climate Change into Municipal Watershed Management in Ontario* [Case study on a project of Toronto and Region Conservation Authority]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change

*Integrating Climate Change into the Planning and Operations of the Apostle Islands
National Lakeshore, Wisconsin*

By: Rachel M. Gregg

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www.nps.gov/apis

Project Summary/Overview

The Apostle Islands National Lakeshore (APIS) in Wisconsin is integrating climate change into its planning and operations. APIS became a member of the National Park Service's Climate Friendly Parks program in March 2008 and is incorporating the overall [National Park Service Climate Change Response Strategy](#) into sustainability efforts on site. In addition, climate change was included in the 2011 APIS General Management Plan (GMP), which acts as a guide for park managers to use in decision making about resource protection, visitor experience and education, and facility development within the park's boundaries. The climate change component of the plan calls for park staff to use an adaptive management approach in addressing climate change on park lands and to engage in scientific studies and inventories to support decision making. APIS has also expanded its educational efforts on climate change and made infrastructure improvements in response to lower lake levels.

Project Background

APIS is located on the northernmost point of the Bayfield Peninsula in Wisconsin. The park includes over 42,000 acres of land on twelve miles of mainland shoreline and 21 islands, plus approximately 27,000 acres of surrounding Lake Superior waters (NPS 2011). The major climate impacts of concern for the park are increasing air and water temperatures and changes in precipitation patterns and extremes, which are projected to cause lower lake levels and decreased winter ice. Some of these changes, such as increasing temperatures and reduced ice cover, have already been documented in the park.

Under the leadership of Superintendent Bob Krumenaker, APIS has incorporated climate change into its operations and broader sustainability efforts. In 2008, APIS joined the Climate Friendly Parks system, created by the National Park Service to provide parks with the resources needed to respond to climate change. The requirements for being a Climate Friendly Park include conducting an emissions inventory, creating a reduction strategy, developing an Action Plan, and increasing education and outreach on climate change issues. The [Apostle Islands National Lakeshore Action Plan](#) includes metrics to achieve these goals; the park has made a number of strides in its reduction strategy, including increasing the use of biodiesel and running many facilities within the park's property on solar power. In addition, APIS has incorporated climate change into its GMP, expanded its educational and interpretive efforts to emphasize climate change, and made infrastructure improvements where possible.

Project Implementation

Park Planning and Operations

The APIS GMP is intended to guide natural and cultural resource management in the park for the next 15-20 years. This process began in 2005 and was completed in 2011. Climate change was not one of the initial focus areas but with the direction of Superintendent Krumenaker, it was incorporated as an important regulatory and management issue for the park's natural and cultural resources, facilities, and visitors. The plan includes desired conditions (e.g., APIS is a carbon neutral park that promotes climate change awareness and education and incorporates adaptation into its operations) and strategies to achieve those conditions (e.g., reducing greenhouse gas emissions, increasing educational efforts and interpretive exhibits, conducting scientific and monitoring studies, engaging in scenario planning efforts). It is not a prescriptive plan for how to respond to climate change but the inclusion of climate change as a major issue affecting the park supports the justification to study and reduce the extent of impacts where possible, and enhances the development of a climate-informed management perspective.

Education and Interpretation

APIS has made strides in expanding its educational and interpretive efforts with regards to climate change. The Northern Great Lakes Visitor Center Climate Change Exhibit was designed with the support of the National Park Service, U.S. Forest Service, the University of Wisconsin, and the Great Lakes Indian Fish and Wildlife Commission. The "Changing Climate, Changing Culture" exhibit includes the effects of climate change on the native Ojibwe culture and other residents in the region. In addition, APIS and its partners received a grant through the 2012 Parks Climate Change Program to take the messages from the exhibit and transform and apply them into a local curriculum for school teachers.

Infrastructure Improvements

APIS has also made changes to infrastructure on site in response to some of the more noticeable effects of a changing climate, such as lower lake levels. Lake Superior experienced record low levels in 2007. As lake levels declined, the park lost between 25-50% of its functional dock space; shallower water exposed the docks' beams, leaving the docks high above the water line and putting boaters and their boats at risk. Park staff had to weigh the costs and benefits of infrastructure retrofitting to meet the needs of boaters while also finding a cost-effective, sustainable approach; these decisions were complicated by the uncertainty in many models around how climate change will drive lake level changes in the region. With the support of a \$12,000 grant from Friends of the Apostle Islands National Lakeshore, park management decided to lower the surface level of some docks by six to twelve inches and install vertical rails to protect boats from being trapped underneath. These docks are not flexible or adjustable in any way, but the vertical rails support a wider flexibility of conditions (e.g., boats can bump against the rails rather than getting swept under the dock and the rails provide boaters with a stable structure on which to tie their boats). The park also competed successfully for NPS infrastructure funding to completely replace three old park docks, and built each one with a lower surface than what it replaced.

Project Outcomes and Conclusions

APIS has taken advantage of opportunities to become a climate-smart park in its planning, operational, and educational efforts. Through all of its activities, APIS has benefited from strong partnerships, especially within the northern Wisconsin sustainability community, and from strong leadership. Superintendent Krumenaker is the lead of an formal regional climate change task force,

which developed in 2012 a Midwest regional strategy based upon the four tenets of the National Park Service's Climate Change Response Strategy – Science, Mitigation, Education, and Adaptation.

References

Apostle Islands National Lakeshore Action Plan

<http://www.nps.gov/climatefriendlyparks/downloads/Action%20Plans%20and%20Inventories/APIS%20Climate%20Friendly%20Action%20Plan%20-%20Final.pdf>

NPS (2011). Final General Management Plan/Wilderness Management Plan/Environmental Impact Statement Apostle Islands National Lakeshore Bayfield and Ashland Counties, Wisconsin

<http://www.nps.gov/apis/parkmgmt/gmp.htm>

Status

Information gathered from interview with project contact on May 16, 2012, publications, and other resources.. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Integrating Climate Change into the Planning and Operations of the Apostle Islands National Lakeshore, Wisconsin* [Case study on a project of the Apostle Islands National Lakeshore]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Policy: Create new or enhance existing policies or regulations, Develop/implement adaptive management strategies

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change

Integrating Climate Change into Water Quality Monitoring on the Fond du Lac Reservation in Minnesota

By: Rachel M. Gregg

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Project Summary/Overview

The Fond du Lac Band of Lake Superior Chippewa is taking both mitigation and adaptation measures to prepare for climate change. In addition to reducing emissions and improving energy efficiency on the reservation, the tribe is also incorporating climate change into its water resources monitoring program.

Project Background

The Fond du Lac Band of Lake Superior Chippewa is one of six members of the Minnesota Chippewa Tribe. The Fond du Lac Reservation is located near Cloquet, Minnesota on the St. Louis River, which flows into Lake Superior. The Reservation encompasses 101,000 acres, which includes forests, wetlands, and wild rice waters (Tribal Profile 2012). Climate change impacts to the region include increased air temperatures and changes in precipitation patterns; secondary impacts may include flooding, drought, increased invasive species presence, species range shifts, and species loss. Many cultural and natural resources of importance to the tribe have been identified as being vulnerable to these impacts, including wild rice beds, fish and moose species, and habitat.

The Fond du Lac Band is undertaking both mitigation and adaptation efforts to prepare for and respond to climate change impacts. The tribe formally adopted the Kyoto Protocol in February 2007 and is actively working to increase energy efficiency, reduce greenhouse gas emissions from buildings, and employ green infrastructure techniques such as rain gardens. They are also conducting a monitoring program to create a baseline that can inform the tribe about climate-induced changes and trends in water levels and temperatures.

Project Implementation

Water resources on the reservation include 44,000 acres of wetlands, 96 miles of streams, and 3,000 acres of lakes, 1,500 acres of which are designated wild rice waters (Costa 2004). The Fond du Lac Band Environmental Program's Office of Water Protection has engaged in long-term water temperature monitoring since 2001. Continuous data loggers in the reservation's six primary streams collect water temperature data from early spring to late fall every year. Recognizing that changes in water temperature and hydrology can be strong indicators of climatic change, the tribe, with the assistance of retired U.S. Geological Survey staff, installed continuous water level loggers in the same six streams to collect hydrologic data in 2010; these loggers record a pressure measurement every 30 minutes.

Project Outcomes and Conclusions

The tribe is using the information collected from the *in situ* stream data loggers to inform planning and management decisions with respect to important cultural resources such as wild rice, species, and habitat.

References

- Costa, N. 2004. Fond du Lac Reservation Office of Water Protection Tribal Report under Section 305(b), Clean Water Act. Submitted to the U.S. Environmental Protection Agency Region 5 [www.fdlrez.com/newnr/environ/final%202003%20tribal%20305\(b\)%20report.pdf](http://www.fdlrez.com/newnr/environ/final%202003%20tribal%20305(b)%20report.pdf)
- EPA Region 5 Water Quality Monitoring Newsletter. March 2011. <http://www.sagchip.org/utilities/flashpapers/WaterQualitynNewsletter.swf>
- Tribal Climate Change Profile: Fond du Lac Band. March 2012 http://www.tribesandclimatechange.org/docs/tribes_519.pdf

Status

Information gathered from interview with project contact on March 31, 2011, publications, and other resources.

Citation

Gregg, R. M. (2012). *Integrating Climate Change into Water Quality Monitoring on the Fond du Lac Reservation in Minnesota* [Case study on a project of the Fond du Lac Band of Lake Superior Chippewa]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Monitor climate change impacts and adaptation efficacy

Infrastructure, Planning, and Development: Create or modify shoreline management measures

Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds

By: Rachel M. Gregg

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Project Summary/Overview

The University of Wisconsin (UW)-Milwaukee Great Lakes WATER Institute, the Southeastern Wisconsin Regional Planning Commission (SEWRPC), and the Milwaukee Metropolitan Sewerage District (MMSD), working with several partners, modeled the potential impacts of climate change on combined sewer overflows (CSOs) and separate sewer overflows (SSOs) and resulting possible effects on water quality in the region.

Project Background

Climate change is expected to cause increased air temperatures, altered precipitation, and changes in the intensity and frequency of storm events in the Midwest region. Under the “worst-case” climate change scenario considered under this study, these changes may have second order effects on the number, frequency, duration, and volume of CSOs and SSOs in Milwaukee watersheds (McLellan et al. 2011). The UW-Milwaukee Great Lakes WATER Institute, which serves on the Science Council and the Human Health and Milwaukee Working Groups of the Wisconsin Initiative on Climate Change Impacts (WICCI), and SEWRPC, which serves on both the WICCI Stormwater and Milwaukee Working Groups, worked with several partners to model the effects of climate change on CSOs and SSOs within the 28 municipalities served by the MMSD. The project’s aims were to estimate the effects of a range of mid-21st century climatic conditions on CSOs and SSOs in the region, incorporate findings into the Milwaukee Working Group’s WICCI report, and develop fact sheets and outreach materials.

Project Implementation

Between 2004 and 2007, SEWRPC and MMSD conducted infrastructure planning efforts and updated the regional water quality management plan. As part of the process, the team modeled the MMSD conveyance and storage system to evaluate the frequency of CSOs and SSOs and created a watershed model to assess pollution sources in the region; both models relied on existing climate conditions. For this project, the team used the same models and added in downscaled climate data projections developed by the WICCI Climate Working Group (using IPCC emissions scenario A1B) in order to examine the possible effects of altered precipitation on flows and sewer infrastructure capacity under climate change conditions. The analyses showed that if no improvements are made to MMSD facilities beyond those currently planned and no adaptation strategies are implemented, CSOs and SSOs may increase by mid-century; improving conveyance

and storage facilities could help protect water quality and human health in the region in a changing climate.

The project team was formed as an outgrowth of the activities of the WICCI Milwaukee Working Group. In addition to the UW-Milwaukee Great Lakes WATER Institute, SEWRPC, and MMSD, other project partners included the UW-Madison Center for Climate Research and Brown and Caldwell.

Project Outcomes and Conclusions

This study was part of MMSD's adaptive planning approach and is just an initial step in raising awareness regarding possible climate change effects on water resources in the region. As more reliable projections of meteorological conditions become available, additional studies are possible that may eventually inform how MMSD operates its system.

In addition, SEWRPC, along with the Great Lakes WATER Institute and scientists from UW-Milwaukee and UW-Madison, is conducting a National Oceanic and Atmospheric Administration-funded study of how climate change will affect the water quality of streams in Milwaukee watersheds, specifically in the Kinnickinnic, Menomonee, Milwaukee, and Root River watersheds, the Oak Creek watershed, and the Lake Michigan nearshore area.

References

McLellan, S., M. Hahn, D. Lorenz, G. Pinter, I. Lauko, E. Sauer, D. Bennett, & J. McMullin. (2011). Impact of Climate Change on CSOs and SSOs in Milwaukee Watersheds. Great Lakes Water Institute, Southeastern Wisconsin Regional Planning Commission, University of Wisconsin Madison, University of Wisconsin Milwaukee, and Brown and Caldwell.
<http://home.freshwater.uwm.edu/mclellanlab/files/2012/07/Impact-of-climate-change-on-CSO-MKE.pdf>

Status

Information gathered from project contact's survey responses on March 23, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Investigating the Impact of Climate Change on Combined and Separate Sewer Overflows in Milwaukee Watersheds* [Case study on a project of the Southeastern Wisconsin Regional Planning Commission]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Policy: Create new or enhance existing policies or regulations

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change

London, Ontario's Climate Change Adaptation Strategy

By: Kirsten Feifel

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Project Summary/Overview

The City of London, Ontario, is surrounded by dikes and dams. Changing precipitation patterns, including the duration and frequency of events, may occur in a changing climate and compromise the infrastructure that supports the City of London. To better prepare for the adverse impacts of climate change, the city collaborated with the University of Western Ontario's Department of Civil and Environmental Engineering to assess future precipitation patterns and resulting effects on the city's infrastructure.

Project Background

The City of London has a population of 350,000 and is located in the southwest of the Ontario province. Two tributaries of the Thames River meet near the city's perimeter; to reduce the impacts of flooding from the Thames River, dikes and dams were built in the 1950s. Climate change is expected to increase the city's vulnerability to flooding as higher and stronger flood waters will likely breach the existing dikes and dams.

Project Implementation

To better prepare for the potential impacts of climate change, the city collaborated with the University of Western Ontario's Department of Civil and Environmental Engineering to analyze changes in rainfall intensity, duration, and frequency. A final report was released in 2010 – [*Updated rainfall intensity duration frequency curves for the City of London under the changing climate*](#). Results indicated that the Thames River rainfall intensity and frequency has increased since 1965 and is likely to continue to increase with the onset of climate change. Peak flows for a small storm could increase by 10-15%, while peak flows for a larger storm could increase up to 30% relative to historical norms.

The analysis concluded that the city should consider developing larger stormwater management facilities and reassess existing flood maps. Under the recommendations from the city's Department of Environmental and Engineering Services, the city council passed a two-phase strategy to adapt to climate change: 1) conduct a comprehensive engineering and scientific analysis of existing stormwater infrastructure and capacities, and 2) develop a long-term climate change adaptation strategy to protect public and private property from flood damage.

Project Outcomes and Conclusions

Phase 1, a comprehensive analysis of existing infrastructure and floodwater capacities, was completed in 2011. The report, [*The City of London: Vulnerability of Infrastructure to Climate Change*](#), outlines climate-related impacts to critical facilities, water barriers, pollution control plants, buildings, roads, and bridges. The second phase, long-term visioning and adaptation strategy development, should be completed in 2013.

References

Natural Resources Canada

www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/municipalities/726

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *London, Ontario's Climate Change Adaptation Strategy* [Case study on a project of the City of London, Ontario]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments

Policy: Develop/implement adaptation plans

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change

New York's Climate Smart Communities Program

By: Rachel M. Gregg

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New York Energy Research and Development Authority, www.nyserda.ny.gov
 New York Department of State, www.dos.ny.gov
 New York Department of Transportation, www.dot.ny.gov
 New York State Public Service Commission, www.dps.ny.gov

Project Summary/Overview

The New York Climate Smart Communities program is a partnership between local communities and five state agencies designed to address climate change. Communities voluntarily sign the Climate Smart Communities Pledge and receive technical support and guidance from state agencies. As of August 2012, one hundred and six communities are part of the program; most are located along the Atlantic and Great Lakes coasts.

Project Background

New York will experience increased average temperatures, flooding, extreme weather events, runoff, water supply and quality issues, droughts, shifting habitats and species' ranges, and sea level rise as a result of climatic changes (Frumhoff et al. 2007). The New York Climate Smart Communities Program is supported by five state agencies – the Departments of Environmental Conservation, State, and Transportation, and the Energy Research and Development Authority and Public Service Commission. It combines mitigation and adaptation responses to limit or eliminate the effects of climate change on local communities (e.g., towns, villages, cities, counties). Benefits of local community involvement include cost savings for local taxpayers through reduced energy costs and increased energy efficiency, increased opportunities for green energy job growth, and improving existing and designing new infrastructure to withstand the effects of climate change (Department of Environmental Conservation 2009).

Project Implementation

The Climate Smart Communities program provides communities with technical support and guidance; as part of the program, each community must adopt a model pledge to reduce greenhouse gas emissions and prepare for climate change. The [Climate Smart Communities Pledge](#) may be adopted by any town, village, city, or county in New York State; it includes a series of steps that communities must take to join the program. These steps include:

- Creating a climate change coordinator position or task force to organize the community's efforts
- Conducting a greenhouse gas inventory

- Developing goals and a climate action plan
- Educating local businesses, organizations, and citizens on efforts that can be taken
- Contributing lessons learned and stories to the Climate Smart Communities Program.

Project Outcomes and Conclusions

One hundred and six [communities](#) have joined the program as of August 2012. The Department of Environmental Conservation recently released the [Climate Smart Communities Guide to Local Action](#), which provides step-by-step guidance and case studies to assist communities; for example, the guide provides information on how to conduct emissions inventories, develop climate action plans, and reduce energy needs.

References

Department of Environmental Conservation's Climate Smart Communities:

www.dec.ny.gov/energy/50845.html

Department of Environmental Conservation. (2009). Climate Smart Communities: A Guide for Local Officials. www.dec.ny.gov/docs/administration_pdf/cscguide.pdf

Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, & D.J. Wuebbles. (2007). *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS). www.northeastclimateimpacts.org/pdf/confronting-climate-change-in-the-u-s-northeast.pdf

Kadlecek, M. (2010). *A Change in Climate*. New York State Department of Environmental Conservation. www.dec.ny.gov/docs/administration_pdf/0210changeinclimate.pdf

Status

Information gathered from interview with project contact, publications, and other resources.

Citation

Gregg, R. M. (2012). *New York's Climate Smart Communities Program* [Case study on a project of New York Department of Environmental Conservation]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Increase/Improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Policy: Develop/implement adaptation plans

Infrastructure, Planning, and Development: Community planning (developing climate-smart communities)

Ontario Regional Adaptation Collaborative

By: Kirsten Feifel

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Project Summary/Overview

The Ontario Regional Adaptation Collaborative (RAC) has focused its climate change adaptation efforts on three themes: extreme weather risk management, water management, and community development planning. Proposed projects will be completed by December 2012.

Project Background

The RAC Climate Change Program's goal is to promote climate change adaptation planning in Canadian communities. The Ontario RAC is focusing its efforts to improve the province's resilience to climate change. The effort is being led by the Ontario Ministry of the Environment with partners in the Ontario Ministry of Natural Resources, Ontario Ministry of Municipal Affairs and Housing, Clean Air Partnership, Ontario Centre for Climate Impacts and Adaptation Resources, Toronto and Region Conservation Authority, Association of Canadian Educational Resources, Institute for Catastrophic Loss Reduction, York University, and Toronto Public Health. The total budget for the Ontario RAC is \$6.8 million, \$3.3 million of which was provided by Natural Resources Canada.

Project Implementation

The Ontario RAC has focused on three themes to help advance regional adaptation to climate change: extreme weather risk management, water management, and community development planning. Case studies and risk assessment and management tools will be used to develop a broad risk assessment tool for vulnerability to extreme weather in Ontario. Results from the study will be used to create a more resilient built environment and to better manage risks to human health during periods of extreme heat. To protect water resources, the Ontario RAC is developing a climate change and water resources technical experts network and a knowledge exchange forum for practitioners to exchange ideas, network and share lessons learned from water management projects. Finally, the Ontario RAC will train staff from at least 50 communities on how to incorporate climate change impacts into long-term management strategies.

Project Outcomes and Conclusions

All of the Ontario RAC projects will be completed by 2012, the end date for the entire RAC Program.

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *Ontario Regional Adaptation Collaborative* [Case study on a project of Natural Resources Canada and the Ontario Ministry of Environment]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments

Pennsylvania Sea Grant's Climate Change Outreach and Research Projects

By: Rachel M. Gregg

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Project Summary/Overview

Pennsylvania Sea Grant (PASG) has addressed climate change issues throughout the state by providing research, education, and outreach to local coastal communities. Their projects have examined the possible risks and vulnerabilities to coastal communities and natural ecosystems in the state. PASG staff have created educational materials and tools to support public awareness and decision making in the state.

Project Background

Pennsylvania contains numerous habitats and species of importance. Sixty percent of the state is forested and 83,000 miles of rivers and streams flow through the state and out to the Delaware Estuary and Lake Erie; 25,000 species have been documented in the state, many of which are threatened or endangered (DCNR 2012). Climate change will have both positive and negative effects on the natural and economic systems of Pennsylvania. Impacts that are already occurring or projected to occur include increased temperature extremes, increased storm and heavy rain events, decreased winter snowpack, increased precipitation, and northward range shifts (UCS 2008). PASG has engaged in many different projects that examine the vulnerability of built and natural environments to the impacts of climate change; in addition, staff have developed and applied outreach materials and climate-related tools to support climate literacy and decision making in Pennsylvania.

Project Implementation

Preparing Coastal Communities for Climate Change was a collaboration between PASG, the Great Lakes Sea Grant Network, and the National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory. Funded through a NOAA Sectoral Applications Research Program (SARP) grant, the project staff examined climate change impacts, such as sea level rise, increasing frequency and severity of storm events, coastal erosion, and increased weather variability, on coastal infrastructure sectors (e.g., ports, marinas, stormwater systems, community planning). The project resulted in the creation of a website, fact sheets, webinars, presentations and other outreach materials that served to elevate PASG's climate change efforts.

The *Erie County Climate Adaptation Workshop* was held in September 2010 with a \$30,000 grant from the NOAA National Sea Grant Coastal Communities Climate Adaptation Initiative (CCCAI). This workshop was held to educate the public and local decision makers on the projected impacts of a changing climate and resulting effects on natural and human systems in Erie County. The goals of the workshop were to enhance understanding and foster a collective climate-resilient mindset for the community, encourage collaboration to improve decision making, introduce climate change

adaptation, and develop adaptation strategies that could be incorporated into existing policies and plans.

Climate Change in Pennsylvania – How Will it Impact You? was a series of three webinars sponsored by a NOAA SARP grant that provided climate change information statewide. The webinars were held in 2010 and focused on climate change trends and impacts and the effects on public beach access, erosion, and North American forests. The recorded webinars are archived and available for download on the [PASG website](#).

Climate Change and Aquatic Invasive Species (AIS) was a project that researched the potential increase in habitat suitability for the introduction, distribution, and establishment of AIS in a changing climate. The effects of AIS are largely unknown, although some studies estimate that increased temperatures will allow some species to expand their ranges into different regions. Three different climate scenarios were examined with respect to the possible range shifts of species in order to identify and prioritize those with the highest likelihood of expanding their ranges into Pennsylvania. Approximately 50 fish, plant, and invertebrate species that are currently not found in the state have been found to be possible invaders under future climate scenarios. Four species were identified as “high risk”, having both high establishment and invasiveness potential. Project staff used the U.S. Geological Survey’s Non-Indigenous Aquatic Species database to inform their findings. The outcome of the project was a framework for allowing resource and AIS managers to develop proactive control and management strategies for dealing with AIS.

Project Outcomes and Conclusions

PASG is looking to continue its education and outreach efforts about the effects of climate change. Challenges encountered throughout these projects include sustained funding, dedicated staff, and the identification of barriers that policy and decision makers have to overcome in order to apply available tools and adopt climate change adaptation strategies.

References

Pennsylvania Department of Conservation and Natural Resources (DCNR)

<http://www.dcnr.state.pa.us/index.aspx>

Union of Concerned Scientists (UCS). (2008). *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. A Climate Impacts Assessment for Pennsylvania.

www.ucsusa.org/assets/documents/global_warming/Climate-Change-in-Pennsylvania_Impacts-and-Solutions.pdf

Status

Information gathered from interview with project contact on March 24, 2011, publications, and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Pennsylvania Sea Grant’s Climate Change Outreach and Research Projects* [Case study on a project of Pennsylvania Sea Grant]. Product of EcoAdapt’s [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts

Natural Resource Management/Conservation: Reduce non-climate stressors likely to interact with climate change

Planning for Climate Change in the Province of Quebec

By: Rachel M. Gregg

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Project Summary/Overview

Quebec has been engaged in developing measures to address climate change since the 1990s. These activities include creating climate-specific institutions, action plans, and, most recently, a formal provincial adaptation strategy.

Project Background

Quebec is the second most populated province in Canada with approximately three percent of the world's freshwater reserves (Boyer 2008). Prominent bodies of water within and surrounding Quebec are the Labrador Sea, Hudson Bay, the Atlantic Ocean, Lake Champlain, and the St. Lawrence River, the primary drainage outlet of the Great Lakes basin. The province's terrain has been shaped by glaciation and scouring, creating three distinct geological zones – the Canadian Shield, the Appalachians, and the St. Lawrence lowlands (McGill University 2011). Quebec is characterized by four climatic zones: humid continental (southern and western Quebec), subarctic (central Quebec), arctic (northern Quebec), and east maritime (eastern Quebec). Climate change in Quebec is expected to cause increased average air temperatures; changes in the timing, duration, and intensity of precipitation; increased extreme events, such as heat waves and droughts; sea level rise and coastal erosion; and decreased snowpack (MDDEFP 2008).

Quebec has been actively engaged in addressing climate change since the 1990s, motivated by two major natural disasters: the July 1996 Saguenay floods and the January 1998 ice storm, which caused billions of dollars in damage and demonstrated the province's vulnerability to such events. The Quebec Government created two climate-specific institutions in 1998 and 2001, respectively, to address climate change issues in the province: the Comité interministériel sur les changements climatiques (Interministerial Committee on Climate Change) and the Ouranos Consortium on Regional Climatology and Adaptation to Climate Change. Ouranos, a private non-profit organization, was created in cooperation with Hydro-Quebec and Environment Canada. The consortium has engaged in a variety of research activities on climate change impacts and adaptation to support informed decision making. Ouranos is also the lead of the Quebec Regional Adaptation Collaborative, a three-year initiative (2009-2012) to fund research focused on the built environment, water resources management, and socioeconomic activities.

Project Implementation

Quebec has released two climate action plans and an adaptation strategy in the last six years. The 2006-2012 Climate Change Action Plan (CCAP), created by the Ministère du Développement durable, de l'Environnement, Faune et des Parcs (MDDEFP; Ministry of Sustainable Development,

Environment, Wildlife, and Parks), called for a reduction of greenhouse gas emissions by six percent below 1990 levels by 2012 (MDDEFP 2008). The plan included 20 mitigation and six adaptation measures. The adaptation actions included creating public health and safety monitoring and early warning systems; consolidating and modernizing existing climate, water resources, and air quality monitoring networks; evaluating and conducting research on permafrost thawing, coastline erosion, and adaptation strategies to mitigate these impacts; assessing the vulnerability of forests and effects on management; enhancing water and air quality management; and supporting the Ouranos Consortium. By 2009, Quebec's greenhouse gas emissions were at 2.5% below 1990 levels and many of the adaptation actions were being implemented. The 2013-2020 CCAP was released in 2012 and builds upon the 2006 version; the new plan updates the original goal of a six percent reduction by 2012 to a more aggressive 20% by 2020 (MDDEFP 2012a).

The 2013-2020 Climate Change Adaptation Strategy (Strategy), which is complementary to the 2013-2020 CCAP, was also released in 2012 (MDDEFP 2012b). The MDDEFP created a working group to support the development of the Strategy; other members included:

- Ministère des Affaires municipales, des Régions et de l'Occupation du territoire (Ministry of Municipal Affairs, Regions, and Territories);
- Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (Ministry of Agriculture, Fisheries, and Food);
- Ministère du Développement économique, de l'Innovation et de l'Exportation (Ministry of Economic Development, Innovation, and Export);
- Ministère de l'Éducation, du Loisir et du Sport (Ministry of Education, Recreation, and Sports);
- Ministère de la Famille et des Aînés (Ministry of Family and Seniors);
- Ministère des Ressources naturelles et de la Faune (Ministry of Natural Resources and Wildlife);
- Ministère de la Santé et des Services sociaux (Ministry of Health and Social Services);
- Ministère de la Sécurité publique (Ministry of Public Security);
- Ministère du Tourisme (Ministry of Tourism);
- Ministère des Transports (Ministry of Transportation);
- Institut national de santé publique du Québec (Quebec National Institute of Public Health);
- Ouranos; and
- Hydro-Québec.

In spring 2010, the working group held eleven workshops to solicit stakeholder input from practitioners, managers, and researchers on climate change impacts and priorities. In August 2010, additional meetings were held with representatives from industry, environmental groups, and municipal authorities to gather input on concerns and potential adaptation strategies. The strategy was released for expert and public comment in September 2011 and February 2012, respectively.

The Strategy adopts fourteen of the principles outlined in Quebec's [Sustainable Development Act](#): health and quality of life, social equity, environmental protection, economic efficiency, participation and commitment, access to information, subsidiarity, collaboration and cooperation, prevention, precaution, protection of cultural heritage, biodiversity preservation, respect for ecosystem support capacity, and responsible production and consumption. The Strategy focuses on the four most vulnerable sectors of Quebec – human health and well-being, economics, built environment, and

natural systems. Adaptation actions are focused around eight strategic directions and 17 objectives, and will be implemented with the financial and technical support of government agencies.

Project Outcomes and Conclusions

Quebec has taken a number of actions to address climate change. Until 2020, the 2013-2020 CCAP target of a 20% reduction in greenhouse gas emissions below 1990 levels and the Strategy will guide the province's actions on climate change. The Quebec Government plans to create mechanisms for monitoring and evaluating the Strategy. MDDEFP is responsible for coordinating the overall development and revision of the Strategy, while all government agencies will be responsible for implementing and evaluating the adaptation actions therein.

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- MDDEFP – Quebec in Action: http://www.mddep.gouv.qc.ca/changements/plan_action/index-en.htm

Status

Information gathered from publications and other resources.

Citation

Gregg, R. M. (2012). *Planning for Climate Change in the Province of Quebec* [Case study on a project of the Ministère du Développement durable, de l'Environnement, Faune et des Parcs (Ministry of Sustainable Development, Environment, Wildlife, and Parks)]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Monitor climate change impacts and adaptation efficacy

Policy: Develop/implement adaptation plans, Create new or enhance existing policies or regulations

*Preparing for Climate Change in the Great Lakes Region*²⁶¹

By: Kirsten Feifel

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Project Summary/Overview

In June 2008, Michigan Sea Grant hosted forty representatives from Great Lakes foundations, non-governmental organizations, agencies, and universities at a one-day symposium entitled “Preparing for Climate Change in the Great Lakes Region.” Collaborators included the Mott Foundation, Joyce Foundation, Kresge Foundation, the Great Lakes Fishery Trust, and the University of Michigan. The focus of the workshop was specifically on adaptation measures to climate change. The objective of the workshop was to identify policy changes and implementation strategies that will enable the Great Lakes region to adapt to climate change and protect major ecosystems. In February 2009, Michigan Sea Grant published the results of the workshop in a [summary report](#). The document includes guiding principles for adaptation, areas for policy change, and short case studies that exemplify key recommendations and implementation strategies in other cities.

Project Background

The workshop originated after multiple, informal conversations amongst regional foundations about how the Great Lakes basin could adapt to climate change. Workshop participants were considered to be leaders within their field on climate change with representatives from the federal government, foundations, academia, and advocacy groups. The goals of the workshop facilitators were to begin a dialogue with key regional players, learn from one another, and discuss regional adaptation strategies and funding priorities.

Key recommendations and actions discussed during the workshop included:

- Reorganizing fiscal policies so that activities that enhance adaptive capacity have a monetary incentive
- Charge for actions that damage the environment and use extra funds for restoration and adaptation measures
- Re-evaluate the economic value of a healthy, functioning ecosystem
- Use local land-use planning and development to increase protection of essential habitat (i.e. floodplains, wetlands) and promote low impact development
- Collaborate with local watershed councils and land trusts
- Partner with neighboring municipalities, industries, and other stakeholders to created integrated watershed management plans
- Provide outreach to city planners, local authorities, and citizens
- Revise shoreline land use regulations to deal with property rights if the Great Lakes' water levels drop as predicted by models

²⁶¹ Also available at <http://www.cakex.org/case-studies/415>

- Develop water conservation and efficient use policies
- Remove water use subsidies so consumers pay the true cost of water
- Ratify and implement the Great Lakes – St. Lawrence River Basin Water Resources Compact
- Attain funds from Congress to enhance regional water conservation infrastructure
- Protect and restore wetlands through economic incentives and zoning measures
- Evaluate the efficacy of existing wetland restoration programs to assess strengths and weaknesses
- Develop a map to prioritize wetland acquisition and restoration efforts
- Where feasible, remove dams to enhance wetland integrity or, on dammed rivers, adjust water regimes to respond to climate change impacts
- Redefine the 100-year floodplain maps to consider the effects of climate change to moderate development in vulnerable areas

Project Implementation

Michigan Sea Grant was awarded funds to organize, host, and write the workshop report. Four foundations (Mott Foundation, Joyce Foundation, Kresge Foundation, and the Great Lakes Fishery Trust) contributed equally to the project. Having multiple foundations contribute to the workshop may have been advantageous because it elevated the importance of the meeting, particularly to grantees, and fostered a sense of ownership within contributing foundations. In general, the number and composition of participants was thought to be appropriate for the workshop; however, state government officials were underrepresented, possibly because only mandates and items of high political priority receive attention during a time of fiscal contraction, and therefore their ability to travel was limited.

Project Outcomes and Conclusions

The workshop report, [*Preparing for Climate Change in the Great Lakes Region*](#), was released in February 2009. Participants, particularly foundations, have continued *ad hoc* discussions and have identified three opportunities of interest:

- Supporting watershed level assessments on the likely impacts of climate change and ways to help prepare and enhance the resilience of the systems
- Surveying state natural resource agencies to assess needs in terms of resources, tools, knowledge, concerns and interests
- Researching existing state and local policies that could be enhanced to help adapt to climate change and identify any policy gaps

In 2010, the findings of the workshop and the support from many of the participants prompted the University of Michigan, Michigan State University, and Ohio State University to propose the creation of the [*Great Lakes Integrated Sciences and Assessments Center*](#) (GLISA), which is funded by the National Oceanic and Atmospheric Administration and through additional support from the universities. GLISA's focus is on agriculture, watershed management, and natural resources-based recreation and tourism within the watersheds of Lake Huron and Lake Erie as well as the broader Great Lakes Basin; the center has an overarching mission of providing important information and resources to support climate change adaptation.

Overall the workshop was a success, generated some quality recommendations, and served as a foundational step for future conversations on responding to climate change in the Great Lakes region. Participants utilized the conference as a knowledge exchange and networking opportunity, which has served as a foundation for new projects focused on adaptation within the Great Lakes region.

References

Michigan Sea Grant. (2009). *Preparing for Climate Change in the Great Lakes Region*.
www.miseagrant.umich.edu/downloads/climate/Climate_Workshop_Report.pdf

Status

Information gathered from interview with project contact, publications, and other resources.

Citation

Feifel, K. M. (2010). *Preparing for Climate Change in the Great Lakes Region* [Case study on a project of Michigan Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Increase/Improve public awareness, education, and outreach efforts, Conduct training and planning exercises

Project Clean Lake: Updating Cleveland's Sewer Systems to Reduce Stormwater Overflows

By: Kirsten Feifel

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Project Summary/Overview

In 2010, the Northeast Ohio Regional Sewer District released the [Project Clean Lake plan](#) to reduce the combined sewer outflow discharge to less than 98% by 2035. The plan was formed after the Environmental Protection Agency (EPA) determined that the sewer district's discharge rates into Lake Erie were in violation of the Clean Water Act. The plan includes a combination of updates to existing infrastructure and the development of green infrastructure to help capture and retain stormwater flow. Climate change is expected to cause an increase in intense precipitation; this project will help to reduce the negative impacts climate change may pose to the city.

Project Background

The Northeast Ohio Regional Sewer District (District) serves more than one million people residing in the greater Cleveland metropolitan area. Three wastewater plants – Easterly, Southerly and Westerly – coupled with over 200 miles of sewer pipes, transport and process over 90 billion gallons of wastewater annually. Roughly 80 square miles of the Cleveland sewer system were designed and built in the late nineteenth century and are commonly referred to as “combined sewers,” where a single pipe carries sewage, industrial waste, and stormwater. During periods of heavy rainfall, urban stormwater runoff can increase greatly, filling and overwhelming the combined sewer pipes. To prevent urban flooding, the Cleveland sewer system has control devices that allow some of the flow to be diverted into regional waterways such as Lake Erie. The District has 126 permitted combined sewer outfalls, where overflow during periods of heavy rainfall may discharge directly into waterways in the greater Cleveland area.

The EPA found the District in violation of the Clean Water Act due to the periodic overflow of untreated wastewater into Lake Erie. In July 2007, the EPA and District filed a Consent Decree specifying new measurements the District would employ to reduce wastewater overflow over the subsequent 25 years.

Among other impacts, climate change is expected to increase extreme weather, including heavy downpours, in the Great Lakes region. The retrofitting improvements to the District's sewer system will reduce the negative impacts that more frequent and intense rainstorms may cause to the Cleveland area.

Project Implementation

Through [Project Clean Lake](#), the District plans to reduce combined sewer overflow by 98% by 2035. The project has an estimated budget of \$3 billion and will be one of the largest infrastructure

projects ever to be completed in Cleveland. Funds for the project will be obtained from the District's customers, who will experience yearly average increases of 13% from 2012-2016.

Initially, the District planned to upsize its "gray" infrastructure – pipes, overflow sites, treatment plants, etc. – for an estimated cost of \$182 million. However, the District also considered a combination of upsized gray infrastructure coupled with the use of green infrastructure to capture and reduce stormwater flow. The District estimated that the inclusion of green infrastructure would actually save the city an estimated \$87 million and achieve better combined sewer outflow capture results.

The EPA approved the District's plan to reduce combined sewer overflows in 2012. The plan includes the installation of seven major deep storage tunnel systems, high-rate wet-weather treatment facilities at all three of the wastewater treatment plants, and the use of green infrastructure to increase the area of permeable surfaces within greater Cleveland to help capture stormwater runoff. The green infrastructure will be designed to manage the flow on-site and will include a combination of rain catchments, permeable surfaces and parklands, and rain gardens.

Project Outcomes and Conclusions

Project Clean Lake will create an estimated 31,000 jobs and generate \$443 million in tax revenue. Its estimated completion date is 2035.

References

Project Clean Lake: Green Infrastructure Plan

http://neorsd.org/images/703/NEORSD_GI_Plan_12282011_project-clean-lake.pdf

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *Project Clean Lake: Updating Cleveland's Sewer Systems to Reduce Stormwater Overflows* [Case study on a project of the Northeast Ohio Regional Sewer District]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Policy: Create new or enhance existing policies or regulations

Natural Resource Management and Conservation: Reduce non-climate stressors likely to interact with climate change

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change, Community planning (developing climate-smart communities), Create or modify shoreline management measures

Quebec City's Environmental Services Adaptation Plan

By: Kirsten Feifel

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Project Summary/Overview

To prepare for the impacts climate change may pose to Quebec City, the Environmental Services Department developed a targeted climate change adaptation strategy. The adaptation plan was approved in 2009 and has 88 adaptation measures, the majority of which are focused on water quality and availability issues. Quebec City plans to use the lessons learned and results from the Environmental Services Department climate change adaptation strategy to develop subsequent adaptation strategies for the entire city.

Project Background

Climate change is projected to increase the frequency of extreme weather – snow storms, wind storms, heat waves, and torrential rain – in Quebec City. Quebec City is located in eastern Quebec, adjacent to the St. Lawrence River. Ouranos, a regional climate change consortium, gave a presentation on the potential impacts of climate change to city leaders in 2006; in response, the city decided to develop a climate change adaptation plan.

Project Implementation

The adaptation plan was initially developed for the city's Environmental Services Department. The city targeted this department because it is tasked to manage the city's natural resources, such as air, water, soil, wastewater, trees, horticulture, and water quality.

The adaptation plan was developed by internal staff and had four main steps:

1. Develop climate change projections for the city for the 2020s, 2050s, and 2080s;
2. Conduct a literature review to ascertain the likely impacts climate change may present to the city's infrastructure and environment;
3. Conduct internal interviews to identify potential adaptation measures; and
4. Prioritize adaptation strategies.

Project Outcomes and Conclusions

The final adaptation plan was approved in April 2009. In sum, 88 adaptation measures were developed, most of them targeting water quality and availability issues. Although the initial focus was on the Environmental Services Department, the city's Executive Committee expanded the adaptation focus to all city operations.

This project was one of the examples provided in Natural Resources Canada's 2010 report, [*Adapting to Climate Change: An Introduction for Canadian Municipalities*](#).

References

Natural Resources Canada

www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/municipalities/841

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *Quebec City's Environmental Services Adaptation Plan* [Case study on a project of Quebec City]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Conduct training and planning exercises

Policy: Develop/implement adaptation plans

Quebec Regional Adaptation Collaborative

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Project Summary/Overview

The Quebec Regional Adaptation Collaborative (RAC) has focused its climate change adaptation efforts on three themes: built environment, water management, and socio-economic activities, including forestry, agriculture, and tourism and recreation.

Project Background

The RAC Climate Change Program's goal is to promote climate change adaptation planning in Canadian communities; for more information, see the program case study, *Canada's Regional Adaptation Collaboratives*. The Quebec RAC is focusing its efforts to improve the province's resilience to climate change by concentrating on three themes – Built Environment, Water Management, and Socioeconomic Activities. The effort is being led by Ouranos Inc. and has over 20 partners in the federal, private, and non-governmental sectors.

Project Implementation

The Quebec RAC has divided its focus on the Built Environment theme into two geographic regions – north and south. The northern group plans to produce a series of maps depicting permafrost characteristics to help inform future building site selections in Nunavik communities as the ground begins to warm. Trainings will be conducted to help community members effectively manage existing infrastructure located on warming permafrost. Finally, village expansion plans and adaptation strategies related to coastal impacts will be developed to help increase the resilience of communities in Nunavik. The southern group plans to focus on issues such as stormwater management, municipal infrastructure vulnerabilities, flooding, and urban heat islands.

The Water Management theme will consider the potential impacts climate change may pose to water resources, infrastructure, and management. In particular, scenarios will be developed to help determine the possible maximum flood loads to evaluate existing dam safety. Conversely, low-flow scenarios will be used to help develop water conservation policies and an early warning, low-flow, and excessive-water-withdrawal warning system for the Yamaska River in southern Quebec. Finally, the Quebec RAC will analyze potential changes to the Ottawa River watershed hydrologic system.

The Socioeconomic Activities theme will analyze the impacts climate change may pose to forestry, agriculture, and tourism and recreational activities to help create tools that will proactively manage sectors to combat the effects of climate change. The forestry group will conduct three pilot projects using ecosystem-based management to assess vulnerabilities to climate change, develop a seed transfer model for the black spruce, jack pine, and white spruce, and develop and improve water

scenarios within Quebec's forests. The agriculture group will analyze case studies to help control agricultural pests in the future, develop an agroclimatic atlas, and update standards for water distribution to agriculture. The tourism group will analyze the impacts climate change may present to the tourism and recreational sectors in Quebec.

Project Outcomes and Conclusions

Many of these projects should be completed by the end of 2012. More information on funded projects may be found in Ouranos fact sheets; some examples include:

- [Producing Predictive Maps of Permafrost Characteristics to Guide the Development of the Built Environment in Nunavik Communities](#)
- [Stormwater Management and Climate Change](#)
- [Adaptation of Dam Safety to Climate Change Impacts by Using Low Recurrence-Interval Floods and by Informing Managers about the Uncertainties](#)
- [Analysis of Socioeconomic Impacts and Adaptation to Climate Change in Quebec's Tourism Industry](#)

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *Quebec Regional Adaptation Collaborative* [Case study on a project of Natural Resources Canada and Ouranos]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments

Rein in the Runoff: Michigan's Spring Lake Stormwater Management Project

By: Kirsten Feifel

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Project Summary/Overview

Over the past few decades, stormwater has increased pollutant loads in Spring Lake, Michigan. In 2007, a collaborative team of researchers began working with the community of Spring Lake to develop an integrated assessment of Best Management Practices (BMPs) to reduce local stormwater impacts. The integrated assessment process involved a detailed assessment of natural, economic, and social issues, future population growth scenarios, and an analysis of potential BMPs. The final report, [*Rein in the Runoff*](#), was released in 2009 and decision-makers are using it to help guide the development and implementation of local ordinances and structural improvements to reduce stormwater impacts.

Project Background

Stormwater runoff is becoming more of a concern as rural and natural lands are transformed into impervious surfaces with the expansion of new urban and suburban development. Impervious surfaces cannot absorb rainwater and instead divert flows into local surface waterways and sewer systems. The increased flow rates in waterways and sewer systems can have many adverse impacts, including erosion, habitat damage, and more frequent flooding. Further, the flows tend to carry more pollutants as they wash away pollutants from impervious surfaces into local waterways and degrade water quality. In the Great Lakes region, climate change is expected to increase the frequency of severe storms and precipitation extremes such as droughts and floods. Thus, stormwater runoff will increasingly become an issue for regional communities.

Spring Lake is a small lake found on the west side of Michigan's lower peninsula and it flows into Lake Michigan via the Grand River. Roughly half of Spring Lake's watershed is forested but the area has become more urbanized over the past few decades. Urbanization and an increase in impervious surfaces have caused higher-than-normal levels of phosphorus in the lake, stimulating the growth of potentially-toxic cyanobacteria blooms and other waterborne pathogens. Indeed, Spring Lake has some of the highest phosphorus concentrations in all of West Michigan. Further, high stormwater runoff has increased shoreline erosion and damaged shoreline infrastructure.

In 2007, Michigan Sea Grant funded a research team, led by researchers at Grand Valley State University's Annis Water Resources Institute, to identify ways to reduce runoff in the Spring Lake watershed. The primary objectives of the project were to:

- Increase the residents' knowledge and engagement in issues related to water resources and quality;
- Identify inconsistencies between state and local regulations designed to improve stormwater management and control; and
- Develop a series of BMPs to help Spring Lake reduce stormwater management issues.

Project Implementation

The Spring Lake Watershed used an Integrated Assessment approach to develop new ways to manage stormwater flows. To complete the process, six steps were undertaken in collaboration with researchers and community members:

1. Define the policy-relevant questions;
2. Document the status and trends of relevant environmental, social and economic conditions;
3. Analyze the consequences of trends in environmental, social and economic conditions;
4. Develop and analyze forecasts of likely future conditions giving consideration to a range of policy and management options;
5. Conduct cost analyses and assess technical feasibility of policy and management options; and
6. Assess uncertainties associated with policy and management choices.

The current and future state of the Spring Lake watershed was assessed using the following research tools:

- a regional wetlands and shoreline assessment,
- a systematic comparison of potential stormwater solutions (both structural and nonstructural-ordinance based BMPs),
- economic analyses of different BMP alternatives, and
- forecasts of future land use and land cover change related to population growth.

Results from the Spring Lake watershed assessment were digested into an integrated assessment stormwater runoff conceptual ecological model. This model highlights the key ecosystem drivers affecting stormwater, stressors to the ecosystem, ecosystem status indicators, societal values, and correlated performance measures. An [atlas of maps](#) was also made to visually display the integrated assessment current, expected and potential future outcomes associated with various BMPs.

To help engage regional stakeholders, the project included the development and ongoing maintenance of a detailed project website – [Rein in the Runoff](#). Baseline information, meeting announcements, summaries, presentations, and other educational information are included on the website. To further increase public engagement, a 47-person stakeholder steering committee was formed to help translate and disseminate project information to their neighbors. The steering committee met quarterly for approximately one year. Their most lively discussion was in regards to proposed changes of local ordinances on water quality and stormwater management.

Researchers found that it was useful to ‘brand’ the project to help increase stakeholder participation. The project title “Rein in the Runoff” helped to increase community acceptance for project results. The brand was developed with stakeholder and research team participation and designed by a volunteer graphic artist.

The research team also distributed a survey within the community to assess local understanding of water quality issues and to serve as an informal educational tool. Results from the survey indicated that most residents understood the potential sources of water pollution to Spring Lake.

Project Outcomes and Conclusions

The project drew to a conclusion in 2009. The integrated assessment successfully combined information about the environmental, economic and social aspects of stormwater management. The research project effectively disseminated information to a wide audience and numerous stakeholder

groups. The primary message was that population growth and development have changed the region's hydrology causing an increase in urban runoff and increased pollutant loads into Spring Lake. Without active management, stormwater runoff could present dire consequences to both the social and natural systems. A combination of structural and nonstructural stormwater BMPs could help to improve water quality. The research team identified their priority BMPs but also recognized that the solutions need to be agreed upon and initiated by the community to be successful.

The *Rein in the Runoff* report is intended to be used as a tool by decision makers to help improve stormwater management. The research team also developed an abbreviated version of the full report – [The Rein in the Runoff Citizens Guide to Stormwater](#) – to continue to increase public engagement and knowledge.

References

Rein in the Runoff Final Project Report

www.miseagrant.umich.edu/downloads/coastal/rein-in-the-runoff/09-206-Full-Report-and-Appendices.pdf

Rein in the Runoff Citizens Guide to Stormwater

www.miseagrant.umich.edu/downloads/coastal/rein-in-the-runoff/Citizens-Guide.pdf

Rein in the Runoff Project Atlas

www.miseagrant.umich.edu/downloads/coastal/rein-in-the-runoff/Watershed-Atlas/Atlas-Introduction-low-res.pdf

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *Rein in the Runoff: Michigan's Spring Lake Stormwater Management Project* [Case study on a project of Michigan Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change, Community planning (developing climate-smart communities)

Sustaining Lakes in a Changing Environment (SLICE): A Long-term Monitoring and Evaluation Program

By: Jessica Hitt

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Project Summary/Overview

Sustaining Lakes in a Changing Environment (SLICE) is the Minnesota Department of Natural Resources' (MDNR) Section of Fisheries' long-term monitoring program. Information on water chemistry, fisheries, habitat, and other biological and chemical indicators is being gathered to assist in the development of management approaches that include a better understanding of how the state's aquatic ecosystems respond to a variety of stressors. The first phase of the project (2008-2012) includes monitoring processes and exploring drivers of change in water quality and fish habitat condition in 24 sentinel lakes across the state's four predominant ecosystem types. The second phase is slated to begin in 2012 and will examine and apply lessons learned from Phase 1 in order to create a robust, long-term lake monitoring program that includes land use and climate change considerations.

Project Background

In 2008, the MDNR received a grant from the State Lottery's Environmental and Natural Resource Trust Fund to develop a statewide, long-term lake monitoring program. Over recent decades, Minnesota has experienced increasing influences from land use changes, which will likely be further exacerbated by climate change. The state's lakes are particularly vulnerable to warming temperatures, changes in precipitation patterns, and a myriad of climate threats. MDNR Fisheries was particularly interested and concerned about the synergistic interactions of human stressors when coupled with the rising threat of climate change.

The SLICE program aims to monitor the region's major stressors (climate change, invasive species, and land use practices) and evaluate the impacts these stressors have on the state's aquatic habitats and fish communities in order to support long-term, sustainable lake ecosystem management. MDNR Fisheries, in conjunction with a coalition of partners, selected 24 sentinel lakes that are representative of the state's major aquatic ecosystem types. These sites are being monitored for physical, chemical, and biological indicators; the data collected will be used to establish baseline information. This baseline data will enable the MDNR and partner organizations to more effectively and efficiently develop climate-smart management strategies and policies to achieve their common goal of sustainable aquatic systems. The information gathered will improve understanding of the lake ecosystems, how they react to stressors, and provide clarity on how stressors might be interacting synergistically. Furthermore, the SLICE program also aims to help managers evaluate the effectiveness of current Best Management Practices as well as future management actions.

The program is being carried out in two phases. Phase 1 (2008-2012) is an intensive survey, that focuses on collecting intensive data from sentinel lakes, giving managers a look at the temporal changes in lake conditions. The second phase, beginning in late 2012, will be an extensive survey, gathering samples from a wider range of lakes, providing a better spatial view of lake conditions across the state. Lessons learned from Phase 1 will be used to inform survey efforts in Phase 2 and focus on indicators that were identified as more sensitive to land use and climate change during the initial survey.

Project Implementation

In previous years, the MDNR has conducted extensive lake surveys through their Lake Survey Program, an effort that covers as many as 2,200 lakes. However, the sporadically collected data was in such small sample sizes and from so many different sites it was insufficient for managers to use to identify the cause-effect relationships needed to shape management response strategies. The SLICE program was designed to gather exhaustive data from sentinel lakes, better enabling statewide managers to understand the cause-effect mechanisms and to predict ecosystem responses to changes in land use and climate.

The program also relies on support from a large group of partner organizations, which allows the program to reach beyond the jurisdiction and capacity of MDNR Fisheries. The program aims to facilitate a close collaboration among stakeholders and usher in a tradition of close cooperation. This collaboration will allow the monitoring program to run efficiently and effectively into the future and to support partners as they work to accomplish their mutual goals of healthy and productive Minnesota lakes. Many of the monitoring activities are being carried out by partner organizations and even private citizens; in addition, MDNR Fisheries works with partner organizations in sentinel lake communities to conduct outreach to inform interested stakeholders about SLICE and its efforts. The SLICE program partners include the:

- Minnesota Pollution Control Agency;
- U.S. Geological Survey Water Science Center;
- Science Museum of Minnesota – St. Croix Watershed Research Station;
- University of Minnesota-Duluth and Twin Cities;
- Natural Resources Research Institute;
- U.S. Forest Service (Superior National Forest);
- Local units of government in the sentinel lakes watersheds;
- Master Naturalist Program; and
- Citizen Lake Monitoring Program.

Establishing the SLICE program required a significant amount of initial work and planning to select sentinel lakes, identify major stressors, and determine appropriate stressor indicators. The 24 sentinel lakes were selected to be representative of the range of ecosystem types found in the state. Minnesota was classified into four ecoregion types (Shield, Forest, Transition, and Prairie) and six lakes were selected from each ecoregion. Lakes were also selected using additional criteria, such as lake stratification, phosphorous concentration, and existence of historic datasets. Eight sampling activities were selected as climate change indicators, including evaporation, ice-off, lake levels, precipitation, relative humidity, solar radiation, tributary flow, and wind energy. Overall, 58 sampling activities are being conducted in Phase 1 that are representative of a variety of indicators, including

climate change, habitat, fish health, land cover, and human health; these activities are being conducted at different frequencies by various program partners. MDNR will examine how selected indicators vary naturally from year to year and identify any incidence of co-variance. This information and other lessons learned from Phase 1 will be used to inform future SLICE efforts.

Project Outcomes and Conclusions

The SLICE program's objectives are to create a statewide, long-term monitoring program that will provide managers with baseline information and data to inform decision-making. The monitoring program aims to provide relevant information on major environment stressors, including climate change and land use, collect data on how those stressors are impacting lake habitats and fish populations, and forecast changes in stressor levels. This monitoring program will also allow managers and partner organizations to develop more effective management and response strategies as well as adaptation policies.

MDNR Fisheries believes that the data collected from SLICE will continue to spur relevant and interesting research projects at the University of Minnesota. Although the SLICE program has benefited from a grant and generous in-kind support from partner organizations, the main concern around program longevity is finding and sustaining other financial and technical support mechanisms.

Status

Information gathered from interview with project contact on August 14, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Hitt, J. L. (2012). *Sustaining Lakes in a Changing Environment (SLICE): A Long-term Monitoring and Evaluation Program* [Case study on a project of the Minnesota Department of Natural Resources]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Monitor climate change impacts and adaptation efficacy

Policy: Develop/implement adaptive management strategies

The Chicago Wilderness Climate Action Plan for Nature

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Project Summary/Overview

In 2010, Chicago Wilderness released its [*Climate Action Plan for Nature*](#), a strategy to help conserve regional biodiversity in a changing climate. This report is the culmination of the efforts of a collaborative team composed of the Chicago Wilderness alliance's 37-member Climate Change Task Force, scientific experts, and large conservation groups. The report outlines three key strategies to prepare for climate change – mitigation, adaptation, and education – and associated benchmark goals to support biodiversity in the greater Chicago Wilderness area.

Project Background

The Chicago Wilderness region is located adjacent to the southern shores of Lake Michigan and spans across the southeast of Wisconsin, northeast of Illinois, northwest of Indiana, and southwest of Michigan. Throughout its 370,000 acres, landscapes are varied and include prairies, wooded communities, wetlands, and metropolitan cities that are home to thousands of native plants and animals.

Established in 1996, the Chicago Wilderness alliance is a regional network of more than 250 organizations that are committed to protecting and restoring the Chicago Wilderness Region. Members of the alliance include local, state, and federal agencies, conservation organizations, cultural and education institutions, volunteer groups, municipalities, corporations, and faith-based groups. The alliance has helped to create and chair the Metropolitan Greenspaces Alliance – a national network of urban conservation coalitions developed to share new strategies and lessons learned across major metropolitan areas.

The alliance has four key initiatives that direct their efforts:

1. Restore nature in the Chicago Wilderness region to health;
2. Protect green infrastructure;
3. Mitigate climate change; and
4. Leave no child indoors.

Their goal is to develop an interconnected network of lands and waterways capable of supporting the natural and metropolitan landscapes of the region. With more than \$13 million in federal funds and more than \$1 million in corporate funds, Chicago Wilderness has implemented more than 500 collaborative projects to help restore and manage the region.

Project Implementation

In 2007, the Chicago Wilderness Executive Council listed climate change as one of its long-term priorities and established the Climate Change Task Force to develop recommendations on how to address potential impacts on the region. In 2008, Chicago Wilderness produced the paper, [*Climate*](#)

[*Change and Regional Biodiversity*](#), a synthesis of projected local impacts expected in a changing climate. Of particular concern was the projected loss of suitable habitat for some species, shifts in temperature regimes, an increased threat of invasive plants and animals and other pathogens, changing water levels of Lake Michigan, and changes in phenology. As such, efforts needed to be made to improve the health of the region's natural areas and make them more resilient to changes in climate.

Beginning in February 2009, the Climate Change Task Force endeavored to develop a first draft of the Chicago Wilderness [*Climate Action Plan for Nature*](#). The task force held bi-monthly meetings, smaller working groups, and an experts' workshop on adaptation. In November 2009, the draft action plan was sent out for review and in February 2010, the [*Climate Action Plan for Nature*](#) was released. The plan outlines proposed actions that could help protect the region in the face of climate change and complements the 2008 [*Chicago Climate Action Plan*](#).

In the Climate Action Plan for Nature, three priority actions were identified – mitigation, adaptation, and engagement. In the official report, each priority strategy is accompanied by supporting goals and actions as well as the entity responsible to oversee its success. Some of the strategies are briefly outlined below:

1. **Reduce greenhouse gases** in the atmosphere to help mitigate the severity of climate change by enhancing local recognition that land conservation and restoration efforts help to sequester carbon dioxide; conducting carbon footprints for member organizations; bolstering efforts to develop a carbon market; and supporting effective climate science.
2. Employ **ecosystem-based adaptation strategies** to make lands more resilient by systematically assessing the vulnerability of terrestrial and aquatic conservation targets to climate change; managing for biodiversity and landscape connectivity; integrating municipality management policies with climate scenarios; and developing a long-term monitoring system to assess the efficacy of adaptation strategies.
3. **Enhance communication** between parties with vested interests in the Chicago Wilderness region by establishing a Climate Clinic program to engage practitioners; building on and advancing existing climate change education programs and tools; and communicating relevant information and lessons learned with key decision makers.

The Chicago Wilderness released a supporting document titled [*Climate Action Plan for Nature: Community Action Strategies*](#). The document outlines how the public can help implement the goals outlined in the Climate Action Plan for Nature by:

1. Creating climate friendly gardens and lawns;
2. Conserving water;
3. Participating in community-based monitoring;
4. Being stewards of the environment; and,
5. Participating in climate change education.

Project Outcomes and Conclusions

The Chicago Wilderness alliance's goal was to generate regional momentum and spur climate change adaptation efforts and awareness. Despite enthusiasm for the project, the alliance was limited in some ways because it lacked a dedicated staff person and funding sources were inconsistent.

The Chicago Wilderness has also been selected to help develop an Upper Midwest and Great Lakes Landscape Conservation Cooperative (LCC). LCCs are landscape-scale partnerships designed to enhance organizational capacity to integrate science, resource management, and conservation goals. Once established, the Upper Midwest and Great Lakes LCC will work to research and protect regional habitats and species from the impacts of climate change and serve as a venue for members to share knowledge and apply the best available science to protect, restore, and manage areas such as the Chicago Wilderness region in a changing climate.

References

Chicago Wilderness Climate Action Plan for Nature, Version 1.0

<http://naturalsystems.uchicago.edu/urbanecosystems/calumet/cdrom/plans/CW%20Climate%20Action%20Plan%20for%20Nature%20final%2017%20March%202010.pdf>

Chicago Wilderness Climate Action Plan for Nature Synopsis

www.chicagowilderness.org/files/2213/3035/6961/Climate_Action_Plan_for_Nature.pdf

Chicago Wilderness Climate Action Plan for Nature: Community Action Strategies

www.chicagowilderness.org/files/6413/3045/0521/CW_CAPN_Action_Strategies.pdf

Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *The Chicago Wilderness Climate Action Plan for Nature* [Case study on a project of the Chicago Wilderness]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Increase/improve public awareness, education, and outreach efforts

Policy: Develop/implement adaptation plans, Create new or enhance existing policies or regulations

Natural Resource Management and Conservation: Enhance connectivity and areas under protection,

Reduce local climate or related change

Infrastructure, Planning, and Development: Create or modify shoreline management measures

The City of Toronto's Climate Change Adaptation Strategy: From Development to Implementation

By: Kirsten Feifel

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Project Summary/Overview

Like many cities in the Great Lakes region, Toronto is already experiencing the impacts and consequences of climate change. To better prepare for the future, the City of Toronto created a comprehensive climate change adaptation strategy in 2008. The development and implementation process of the adaptation strategy is well cataloged in subsequent reports and other documents. As of 2011, the City of Toronto has actively implemented 76 programs or projects designed to help Toronto adapt to climate change.

Project Background

Toronto is the largest city in Canada and the provincial capital of Ontario. It is located on the northwestern shore of Lake Ontario and has over 2.6 million residents. Toronto roughly covers an area of 630 square kilometers and has a 46 kilometer-long waterfront shoreline. Three rivers intersect in the city: the Humber River, the Don River, and the Rouge River. Toronto is a major international center for business and finance and plays an important role in the global economy.

Climate change is expected to have adverse impacts on Toronto. Scientists expect that the city will become more vulnerable to extreme heat, floods, droughts, and pests, and experience increased human health concerns. Toronto Public Health predicts that the number of heat-related deaths will double by 2050 and triple by 2080 due to climate change. Further, the city is expecting to experience warmer winters, which will increase survivorship of insect pests such as the pine beetle and alter winter melt off magnitude, patterns, and timing. Precipitation is expected to increase and extreme weather will be experienced more frequently.

Toronto was one of the first cities in Canada to begin to prepare for climate change. For example, in 1999 Toronto Public Health developed a Health Alert system to help warn residents of heat waves. Multiple initiatives were produced to reduce Toronto's vulnerability to climate change from 1999-2007. In March 2007, the report *[Change is in the Air](#)* was released to the public; it contained 27 skeleton potential climate change actions for public comment. In July 2007, the Toronto City Council unanimously adopted a comprehensive climate change adaptation strategy and committed over \$1 billion to implement the *[Climate Change, Clean Air and Sustainable Energy Action Plan](#)* (Climate Change Action Plan) over the course of five years. The Climate Change Action Plan was considered to be one of the top priorities of the Mayor.

Project Implementation

Six internal core groups were invited to participate in the development of the Climate Change Action Plan: the Mayor's office, City Council's Parks and Environment Committee, the Executive

Environment Team, the Toronto Environment Office, the Adaptation Steering Group, and the Adaptation Core Group. An external committee of regional experts was formed and two external organizations were invited to be involved: the Clean Air Partnership and the Institute for Catastrophic Loss Reduction. The city's overall strategy was to focus on activities that reduce greenhouse gas emissions and help prepare for climate change.

The City of Toronto has committed to reducing emissions by six percent by 2010, 30% by 2020, and 80% by 2050. Funded projects were designed to reduce the city's greenhouse gas emissions and support sustainable development; example projects include:

- Low interest loans to support energy conservation and renewable energy projects;
- Energy retrofits on city owned buildings;
- Tree planting initiatives;
- Expansion of the city's bike plan;
- Conversion of traffic signals to LED lights;
- Improved water efficiency and energy efficiency in the Toronto Water operations;
- Methane gas capture from open and closed landfills; and
- Purchase of electric-hybrid buses.

Beyond reducing greenhouse gas emissions, the Climate Change Action Plan also contains provisions to develop a climate change adaptation strategy. The Toronto Environment Office in collaboration with the City's Adaptation Steering Group and the Clean Air Partnership began developing the adaptation strategy in 2008.

The report, *Ahead of the Storm*, suggests two concurrent types of activities for the city to implement, one focusing on issues that can be handled with short-term actions versus those that need longer term attention and planning. In the report, each short-term adaptation action is categorized by anticipated benefits and city group(s) responsible for implementation. In 2008, sixteen of the 36 short-term climate adaptation actions had the financial resources to begin implementation. Actions varied from developing future climate prediction models to reviewing urban flooding issues to green development projects.

To develop a longer term, comprehensive climate change strategy, the report suggests a nine-step process and also includes recommended actions. In short, the suggested process is to:

1. Create the internal infrastructure and political commitment to support a long-term climate change adaptation strategy;
2. Engage the public, businesses, and other stakeholders;
3. Incorporate climate change adaptation into city policies;
4. Use the best available science to develop future climate scenarios;
5. Use climate scenarios to assess the city's vulnerabilities;
6. Conduct a risk assessment to identify priority areas;
7. Develop and assess adaptation options to reduce risk;
8. Implement effective climate change adaptation strategies; and
9. Monitor the effectiveness of the adaptation strategy and adjust when necessary.

The city held six public consultation meetings. Attendees were invited to discuss and opine on three defining questions:

1. What should the city do to adapt to climate change?
2. What additional things should be added to the adaptation plan?
3. What is missing from the adaptation plan?

On May 21st, 2008, the Climate Change Committee endorsed a Staff Report “Climate Adaptation Strategy” based on *Ahead of the Storm*. The adaptation strategy was later unanimously approved by the City Council on July 15, 2008.

Project Outcomes and Conclusions

Following the successful development and approval of *Ahead of the Storm*, the Ontario Ministry of the Environment provided funds in 2008 to the Clean Air Partnership to develop a report on the ‘lessons learned’ from the development of Toronto’s Climate Change Action Plan. The report, [*Climate Change Adaptation in the City of Toronto: Lessons for Great Lakes Communities*](#), is designed to serve as a resource for other Great Lakes communities that are considering creating their own climate change adaptation strategy. It reviews the process the City of Toronto went through to create its adaptation strategy, the major features of the adaptation strategy, provides a case study of how climate change adaptation has altered stormwater management, and concludes with 19 lessons learned (Penney 2008).

In April 2011, the City of Toronto Environment Office released a [summary](#) of all the projects and programs that Toronto has implemented to support climate change adaptation. The table provides a list of 76 programs or actions, descriptions, and the lead agency or group responsible for implementation. Many of the actions have hyperlinks that provide more detailed information about specific projects or programs.

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Status

Information gathered from publications and other resources.

Citation

Feifel, K. M. (2012). *The City of Toronto's Climate Change Adaptation Strategy: From Development to Implementation* [Case study on a project of the Toronto Environment Office]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct research, studies, and assessments, Conduct training and planning exercises

Policy: Develop/implement adaptation plans

The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region

By: Jessi Kershner

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Project Summary/Overview

Projected climate impacts in the Northwoods region include warmer temperatures, longer growing seasons, shifts in the timing and amount of precipitation, changes in soil moisture patterns, increasing pests and diseases, and more frequent storms, droughts, floods, and wildfires. These changes are likely to significantly affect the forests, ecosystems, and wildlife of the region. To help land managers and landowners prepare for and adapt to potential impacts, researchers at the Northern Institute of Applied Climate Science (NIACS) have led the development of the Climate Change Response Framework. This Framework walks stakeholders through vulnerability assessment and adaptation planning processes and provides users with a set of tools, partnerships, and actions to support climate-smart conservation and forest management.

Project Background

Climate change impacts in the Northwoods region include warmer temperatures, changing precipitation patterns, and more frequent storms, droughts, and wildfires. As a result of these changes as well as current threats such as shifts in fire regimes, invasive species, species decline, and habitat fragmentation, forests and ecosystems of the Northwoods region will likely experience dramatic changes over the next 100 years.

To help address these issues, the Northern Institute of Applied Climate Science (NIACS) has been designed as a collaborative effort among the Forest Service, universities, and forest industry to provide information on managing forests for climate change adaptation. NIACS develops synthesis products on climate change adaptation, carbon cycle science, and bioenergy production; promotes communication about climate change science, forest response, and management strategies through seminars, workshops, and webinars; and works to enhance communication and collaboration between land managers, policymakers, and scientists. Several researchers from NIACS have joined with partners to create the Climate Change Response Framework, a collaborative approach to helping land managers understand the potential effects of climate change on forest ecosystems and identifying ways to integrate climate change into management and planning. The Framework covers three large regions and 11 National Forests in the eastern US: the Northwoods (includes Minnesota, Wisconsin, and Michigan), the Central Appalachians (includes Ohio, West Virginia, and Maryland), and the Central Hardwoods (includes Missouri, Illinois, and Indiana). Funding for these efforts is primarily provided by three branches of the USFS – National Forest System Eastern Region,

Northern Research Station, and Northeastern Area State and Private Forestry. Additional support has been provided by the by Landscape Conservation Cooperatives (LCCs) in the region including the Upper Mississippi and Great Lakes and the Gulf Coastal Plains and Ozark LCCs.

Project Implementation

Each regional project includes four main components: (1) science and management partnerships; (2) vulnerability assessments; (3) adaptation resources; and (4) demonstration projects, and is comprised of six steps:

1. Identify location, ecosystems, and time frame.
2. Establish partnerships.
3. Assess vulnerabilities and mitigation potential.
4. Compile adaptation strategies and approaches.
5. Plan and implement at appropriate scales.
6. Integrate monitoring and evaluate effectiveness.

NIACS staff work one-on-one with National Forest managers, NGOs, tribes, and others to walk them through the process and help them apply and use it within their current planning frameworks.

The Northwoods region is currently the furthest along in the six-step process. A seed grant was awarded for the project in Spring 2009 and the project began the following fall. This first project was focused on forests of northern Wisconsin, with the goals of conducting a vulnerability assessment of forest ecosystems to climate change, examining the mitigation potential of these ecosystems, and considering approaches to adaptation. In Spring 2010, the first workshops were held and brought together landowners and land managers (both public and private including NGOs, tribes, and National Forest managers) to participate throughout the process. Scientists were also brought in to present on the state of knowledge about climate change impacts in northern Wisconsin. In late spring, they produced a draft Vulnerability Assessment that was finalized in Fall 2010 and published in 2011. Using information from the vulnerability assessment, the workshops, and the literature, they also compiled and developed adaptation strategies and approaches relevant to the region. These strategies and approaches, vetted by >30 local experts, were organized into a “menu” for consideration by land managers. An adaptation workbook was also developed to walk stakeholders through the process of how to use vulnerability assessment results and apply adaptation strategies from the menu in their current decision-making and planning processes. These tools were published in a *Forest Adaptation Resources* document. The general approach implemented in Wisconsin is now being expanded and applied to different projects in Michigan and Minnesota, as part of the greater Northwoods Framework. These projects have completed the initial workshops and are currently reviewing drafts of the vulnerability assessment results.

As part of the vulnerability assessment, Northwoods project staff evaluated the vulnerabilities of individual tree species and forest or natural community types. Gridded historical and modeled climate change information, as well as two different modeling approaches (climate envelope and process), were used to model impacts on tree species. A group of experts were also convened to evaluate individual species’ sensitivity and ground-truth model results. The vulnerability assessment results were used to create maps of the ecoregion showing where species in the region might decline in the future

Similar to projects in Michigan and Minnesota, the Central Hardwoods region is in the initial phases of the project. A project team of federal and state land management agencies, conservation organizations, and academic institutions from Illinois, Indiana, and Missouri has assembled. Currently NIACS and Forest Service staff are working with climate impact modelers to develop downscaled historic and future climate information. They have hosted expert panel workshops where modelers and local experts are brought together to consider model results and to begin assessing major threats and changes to wildlife and habitats in the region.

The Central Appalachians region is still in the very beginning phases of the project. As of summer 2012, they have assembled a team of people from federal and state land management agencies, private forest owners, conservation organizations, and others. A vulnerability assessment is in the early stages of determining the analysis area and ecosystem types, and gathering relevant data.

Project Outcomes and Conclusions

The adaptation workbook developed as part of the Wisconsin effort has been published after multiple reviews and tests, and is currently being used with several public, tribal, and private stakeholders. They hope to continue incorporating the adaptation workbook into future projects, and expand its use with adaptation strategies and approaches throughout the Northwoods, Central Hardwoods, and Central Appalachians. They are also updating the Vulnerability Assessment document to incorporate new climate and modeling information.

Challenges from this effort include:

- A range of skepticism among managers and other stakeholders about climate change from ‘the climate is not changing’ to ‘the climate is changing but we can’t do anything about it’ to ‘climate is changing and we can do something but the models are not there yet’.
- Keeping the momentum going among large networks of people can be difficult, particularly if the internal capacity is limited due to other commitments.
- This type of project requires people to be aware of and have access to knowledge in a lot of different areas, as well as a reliance on experts, which can be difficult.
- In states where climatic changes are evident (e.g., Wisconsin and Minnesota), stakeholders support climate adaptation. In states with little to no change in annual or seasonal climate measures (Indiana, Illinois, Missouri), it has been difficult to engage people around climate adaptation.

Status

Information gathered from interview with Leslie Brandt on April 13, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Kershner, J. M. (2012). *The Climate Change Response Framework: Supporting Climate-Smart Conservation and Forest Management in the Great Lakes Region* [Case study on a project of the Northern Institute of Applied Climate Science]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Create/enhance resources and tools

*The Michigan Climate Coalition: Enhancing Networking and Collaboration,
Communication, and Action Around Climate Change in Michigan*

By: Jessi Kershner

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Project Summary/Overview

The Michigan Climate Coalition (MCC), founded in 2010, brings together individuals from non-profit organizations, businesses, government, and educational institutions to enhance networking and collaboration, communication, and action around climate change and adaptation for Michigan. The MCC website – www.miclimatecoalition.org – includes resources, events, funding opportunities, and contact information for those interested in climate science, adaptation, sustainability, and related disciplines.

Project Background

In 2009-2010, Michigan State University (MSU) launched the Climate Change Leadership Fellows Program, which was intended to enhance the state's capacity to deal with climate change. The Program was part of a larger Michigan Agricultural Experiment Station-funded project intended to encourage and provide opportunities for interactions between MSU and key stakeholders in climate change. Fellows included individuals from public and private sectors in Michigan, such as the Michigan Department of Agriculture, The Nature Conservancy, Michigan Department of Natural Resources, Limnotech, Michigan Department of Environmental Quality, Michigan Farm Bureau, City of East Lansing, and others.

The Program was focused on two climate change-related initiatives: (1) a Distinguished Lecture Series on Climate Change that brought leading researchers and policy makers to MSU, and (2) a Climate Change Symposium focused on Michigan's Climate Action Plan as well as previous MSU climate change conferences. Fellows had an opportunity to engage with speakers individually and then meet with the larger group for facilitated discussions and to work on a collaborative project. Although no concrete products came out of this engagement, many of the fellows went on to form the MCC. The goal of the MCC is to foster synergy through information, communication, and action to help Michigan respond to climate change. Funding for the project was provided by a small internal grant for \$15K to house the MCC website (www.miclimatecoalition.org).

Project Implementation

Founded in November 2010, the MCC is a partnership of universities, businesses, non-profit organizations, and government agencies, and is open to anyone interested in climate science, sustainability, and related issues. The MCC is primarily focused on three objectives:

1. **Networking and collaboration.** The "Climate ID" project collects climate-related information about work being done in Michigan to provide a single point of access for

those interested in tracking and engaging in climate change efforts to help reduce duplication of climate efforts and encourage collaboration. This includes information such as reports, initiatives, events, and funding opportunities and are shared through the MCC website (www.miclimatecoalition.org).

2. **Communication and translation.** The MCC translates technical reports and other documents to make the information more accessible and understandable by a wider audience. This helps to better link the scientific community and decision makers.
3. **Action and filling in gaps.** The MCC identifies where there are gaps in knowledge to facilitate identification and development of targeted research to fill those gaps.

The MCC has also formed 10 topic-specific subgroups that organize climate change activities and research by sector including: agriculture, coastal and Great Lakes, education and outreach, energy, forests, health, inland waters, municipalities and transportation, land use and planning, and wildlife and terrestrial ecosystems.

Project Outcomes and Conclusions

Individual MCC Working Groups have brought together people from public and private organizations that would not necessarily have had a chance to connect and discuss climate change and adaptation. Additionally, many MCC Working Groups have organized conferences or symposiums to facilitate broader information sharing with other sectors and across different issues. The hope is to understand where gaps exist, identify redundancies, and discover ways in which diverse issues can be addressed collaboratively. The MCC is currently trying to raise additional funds to hire a part-time coordinator.

Status

Information gathered from interview with Maya Fischhoff on March 30, 2012. Case study reviewed by interviewee.

Citation

Kershner, J. M. (2012). *The Michigan Climate Coalition: Enhancing Networking and Collaboration, Communication and Action Around Climate Change in Michigan* [Case study on the Michigan Climate Coalition]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Increase/improve public awareness, education, and outreach efforts, Conduct training and planning exercises

The National Oceanic and Atmospheric Administration's Great Lakes Climate Initiatives

By: Kirsten Feifel and Jessica L. Hitt

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Project Summary/Overview

The National Oceanic and Atmospheric Administration (NOAA) is involved in multiple climate-related projects and initiatives in the Great Lakes region. Some highlights include: [Climate Ready Great Lakes](#), a three module set of training presentations to help develop a region that is “climate ready”; a [supplement](#) to the report [Adapting to Climate Change: A Planning Guide for State Coastal Managers](#) specific to the Great Lakes region; and a series of climate preparedness workshops. Many of these projects have been funded through the Great Lakes Restoration Initiative.

Project Background

NOAA has developed region-specific teams in order to develop a flexible network to help coordinate national efforts with regional collaborators. There are eight geographical regions: Alaska, Central, Great Lakes, Gulf of Mexico, North Atlantic, Pacific Islands, Southeast and Caribbean, and Western. The regional teams engage partners and stakeholders and build and maintain relevant relationships within their dedicated region. They also monitor regional activities and help to facilitate collaboration between NOAA offices and their partners. The Great Lakes Regional Collaboration Team was established in 2004. The Team, along with other NOAA entities, has invested in capacity building around climate change in the Great Lakes, including training modules, a regional report, and workshops.

Project Implementation

The NOAA Great Lakes Regional Collaboration Team partnered with the Great Lakes Sea Grant Network to produce *Climate Ready Great Lakes*, a three module set of presentations to help practitioners and managers prepare for climate-related impacts. Each module contains a pre-designed presentation with a script, supplemental materials, worksheets, handouts, and evaluation forms. The modules were designed to act as standalone presentations or to be covered sequentially.

- **Module 1**, *What am I adapting to?*, covers observed and predicted climate change impacts on the Great Lakes. It also aims to provide users with examples of how communities are preparing for climate change.
- **Module 2**, *Developing a Climate Adaptation Plan*, outlines a planning process to help identify climate-related vulnerabilities and identifies specific adaptation strategies that may be incorporated into plans.
- **Module 3**, *Climate Change Adaptation Tools*, introduces resources and tools that have been developed to help local communities adapt to climate change.

In 2009, the U.S. government dedicated \$475 million to help restore the Great Lakes region through the Great Lakes Restoration Initiative (GLRI), which is the largest investment in the restoration of

the Great Lakes in two decades. Funding from the GLRI was used to develop a Great Lakes-specific supplement to the 2010 report, *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. The [supplemental report](#) expands upon the initial nationwide report by providing regionally-specific climate trends in and potential climate change impacts on the region. The 76-page report has sections that focus on predicted impacts on and consequences for the Great Lakes region, adaptation planning strategies and efforts, and specific adaptation examples (Cruce and Yurkovich 2011).

In addition, NOAA's National Estuarine Research Reserve (NERR) System, along with several partners, has hosted a series of climate planning workshops in the Great Lakes. The NERR piloted these trainings along with Washington Sea Grant in the Padilla Bay NERR in 2009 (Gregg 2010). Similar workshops were held in 2011 in Cleveland, Ohio, Green Bay, Wisconsin, and Duluth, Minnesota. These workshops were one-day events that addressed regional climate change issues and the needs of regional planners and other professionals to develop targeted adaptation actions to prepare for the anticipated impacts of climate change. The workshops were funded through the Great Lakes Restoration Initiative. Other sponsors included the Old Woman Creek NERR, Lake Superior NERR, Ohio Coastal Training Program, Ohio Department of Natural Resources, Ohio Sea Grant, Ohio Coastal Management Program, University of Wisconsin Extension, The Ohio State University, Ohio Lake Erie Commission, and the NOAA Coastal Services Center. Workshop materials and videos are available on the [NERR Climate Change in the Great Lakes website](#).

Project Outcomes and Conclusions

NOAA has strongly invested in capacity building efforts in the Great Lakes region. NOAA is also a partner in a variety of regional projects and programs, including the National Wildlife Federation's Climate-Smart Restoration Partnership.

References

- Gregg, R. M. (2010). *The National Estuarine Research Reserve's "Planning for Climate Change" Workshop* [Case study on a project of the Padilla Bay National Estuarine Research Reserve and Washington Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/849> (Last updated March 2010)
- Cruce, T., & Yurkovich, E. (2011). *Adapting to Climate Change: A Planning Guide for State Coastal Managers - A Great Lakes Supplement*. Silver Spring, MD: NOAA Office of Ocean and Coastal Resource Management.
<http://coastalmanagement.noaa.gov/climate/docs/adaptationgreatlakes.pdf>

Status

Information gathered from survey responses from Heather Elmer on May 9, 2012, interview with Heather Stirratt on June 21, 2012, publications, and other resources.

Citation

Feifel, K. M., & Hitt, J. L. (2012). *The National Oceanic and Atmospheric Administration's Great Lakes Climate Initiatives* [Case study on projects of the National Oceanic and Atmospheric Administration]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments,

Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

The National Wildlife Federation's Climate-Smart Restoration Partnership in the Great Lakes

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Project Summary/Overview

The Climate-Smart Restoration Partnership (CSRP), created by the National Wildlife Federation (NWF), is focused on providing technical assistance for climate-smart coastal restoration projects in the Great Lakes region. NWF, in collaboration with the National Oceanic and Atmospheric Administration (NOAA) and EcoAdapt, has developed technical guidance and provided training to support the planning and implementation of regional restoration projects that incorporate climate change information. This guidance provides users with tools and a framework to approach restoration given the reality of climate change. The CSRP also supports training workshops to build capacity in the region.

Project Background

Coastal habitats in the Great Lakes region experience numerous stressors, including pollution, habitat degradation, invasive species establishment, overfishing, and, increasingly, climate change. The region is vulnerable to a number of climate threats that may exacerbate or magnify existing stressors, including warming water and air temperatures, changing precipitation patterns and flow regimes, changing lake levels, and reduced ice cover. These impacts are threatening restoration and conservation activities; in order for these projects to be successful in a changing climate, the approaches need to be examined through the climate lens.

The purpose of the CSRP is to develop climate-smart restoration guidance for and build upon the efforts of NOAA and other regional organizations and initiatives [e.g., the Great Lakes Restoration Initiative (GLRI)] as they design, implement, and evaluate climate-smart restoration policies, plans, and implementation criteria. NWF and EcoAdapt have partnered to create technical guidance, provide training and assistance, test this guidance on-the-ground, and revise as necessary.

Project Implementation

The CSRP includes three components: technical guidance, training and assistance, and pilot restoration projects.

Technical guidance

NWF and EcoAdapt developed the 2011 technical guidance document, [*Restoring the Great Lakes' Coastal Future*](#), to aid NOAA and partners in planning and implementing climate-smart restoration projects (Glick et al. 2011). The guidance document serves as a climate-smart framework for restoration, providing users with a suite of tools and a methodology to approach restoration given

the reality of climate change. The framework was designed to be iterative, inclusive, and replicable by practitioners and managers across the region and the country in multiple scales and habitats. The framework is regionally tailored to assist managers as they work to conduct vulnerability assessments and develop and implement climate-smart restoration projects.

The methodology includes six steps:

7. Identify restoration-specific goals and targets
8. Identify possible approaches to restoration projects
9. Conduct a vulnerability assessment of both goals and targets and project approaches
10. Develop climate-smart management options
11. Prioritize and implement specific management options
12. Monitor, evaluate, and revise restoration approaches

The guide provides regional sample case studies of how projects could incorporate climate-smart restoration framework into their work. These examples, including the restoration of whitefish spawning habitat and sea lamprey control, are presented in tabular format for easy reference. Tables review vulnerability of project goals, targets, and approaches to climate change and present options for reducing that vulnerability on a number of levels. More detailed information on conducting a vulnerability assessment and additional resources on restoration, climate change adaptation, and the Great Lakes region are provided in appendices.

Training and assistance

The project also includes training workshops and webinars, designed and hosted by NWF and EcoAdapt in order to educate participants about climate change impacts and science, provide training to support climate-smart decision making in restoration activities, act as a forum through which participants can network and build a community of practice around climate-smart restoration, and share lessons learned and resources developed.

Pilot restoration projects

Additionally, NWF and EcoAdapt are providing guidance to NOAA to ensure that relevant pilot projects include climate change in their design, implementation, and evaluation. These [projects](#), which are at different stages of design and implementation, include:

1. Little Rapids Habitat Restoration (MI)
2. Muskegon Lake Restoration Project (MI)
3. Crow Island State Game Area Marsh Enhancement Project (MI)
4. Clinton River Spillway Habitat Restoration Planning & Design Macomb County (MI)
5. Lower Black River Habitat Restoration (OH)
6. Riparian Restoration in the Buffalo River Area of Concern (NY)
7. Ottawa National Wildlife Refuge Restoration in Maumee Bay Area of Concern (OH)

Project Outcomes and Conclusions

The guidance document, *Restoring the Great Lakes' Coastal Future*, is being applied by NOAA and its grantees in restoration efforts; the first update to the report is expected in early 2013. The partners hope to use the seven pilot projects as case study examples of successful climate-smart restoration efforts in future iterations of the guidance document. Lessons learned from the seven pilot projects will directly influence the first update of the report.

The resources and guidance provided through this partnership are applicable to other regions and habitats throughout the world. An important facet of the CSRP is that the partners have identified metrics for success; examples of these include: restoration projects and initiatives incorporate climate change into planning and implementation, CSRP-developed methodologies are employed at multiple scales and in different ecosystems, and increased funding is available for climate-smart habitat restoration projects in both the public and private sector. All of the pilot projects are required to monitor and evaluate success.

References

Glick, P., J. Hoffman, M. Koslow, A. Kane, and D. Inkley. (2011). Restoring the Great Lakes' Coastal Future: Technical Guidance for the Design and Implementation of Climate-Smart Restoration Projects. National Wildlife Federation, Ann Arbor, MI.
http://www.nwf.org/~media/PDFs/Global-Warming/Climate-Smart-Conservation/NWF_Restoring_the_Great_Lakes_Coastal_Future_090211.ashx

Status

Information gathered from interview with project contact on September 7, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. & Hitt, J. L. (2012). *The National Wildlife Federation's Climate-Smart Restoration Partnership in the Great Lakes* [Case study on a project of the National Wildlife Federation and EcoAdapt]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Natural Resource Management and Conservation: Incorporate climate-smart guidelines into restoration

The Ontario Centre for Climate Impacts and Adaptation Resources' Climate Adaptation Initiatives

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Project Summary/Overview

The Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is mandated to communicate climate science, facilitate the development and implementation of adaptation strategies, cultivate local and regional partnerships, and support the measures recommended by Ontario's Expert Panel on Climate Change Adaptation. To this end, OCCIAR has undertaken a number of projects and programs, including creating and hosting stakeholder workshops and developing outreach materials to support adaptation action, as well as engaging in a planning process to support the development of an adaptation plan for Lake Simcoe.

Project Background

Climatic changes in the province of Ontario will include increasing air temperatures, extreme storms and precipitation events, decreasing lake levels, increasing incidence of wildfire and pests, and habitat and biodiversity loss. The Government of Ontario created an Expert Panel on Climate Change Adaptation in 2007 and released [*Climate Ready: Ontario's Adaptation Strategy and Action Plan 2011-2014*](#) in 2011. OCCIAR supports these and other activities by building capacity for climate change adaptation in the province. As part of its mission, OCCIAR maintains the Climate Change Adaptation Community of Practice (CACC; www.ccadaptation.ca), an interactive online resource that supports the exchange of information on climate change adaptation between provincial practitioners, including representatives from the government, academia, and industry. OCCIAR has also engaged in the Community Adaptation Initiative, the Ontario Regional Adaptation Collaborative, and the Lake Simcoe adaptation planning process.

Project Implementation

1. Community Adaptation Initiative

The Community Adaptation Initiative is a climate outreach project supported by OCCIAR and the Clean Air Partnership and funded by the Ontario Ministry of the Environment. The partners are working to develop outreach materials on impacts, vulnerability, and risks, and host training and planning workshops to build capacity and facilitate adaptation action among the private and public sectors.

Materials

- The Clean Air Partnership developed five case studies of municipal adaptation in practice in Ontario, including:
 - [Integrating Climate Change Adaptation into the Town of Ajax Official Plan](#)
 - [Adapting to Changing Flood Patterns in the City of Hamilton](#)
 - [Creating a Regional Climate Change Strategy in Peel](#)
 - [Community Based Adaptation in Brampton Through the Sustainable Neighbourhood Retrofit Action Plan](#)
 - [A Street Tree Survival Strategy in Toronto](#)

- OCCIAR developed a series of fact sheets on different topics relevant to climate change adaptation in the region; these include:
 - [Adaptive Management in Climate Change Adaptation](#)
 - [Agriculture: in a changing climate](#)
 - [Ecosystems: in a changing climate](#)
 - [Human Health: in a changing climate](#)
 - [Forests and Forestry: in a changing climate](#)
 - [Mining: in a changing climate](#)
 - [Tourism and Recreation: in a changing climate](#)
 - [Climate Change Impacts and Adaptation for Urban Regions](#)
 - [Terrestrial Invasive Species: in a changing climate](#)
 - [Aquatic Invasive Species: in a changing climate](#)
 - [Risk Assessment Process in Climate Change Adaptation](#)
 - [Vulnerability Assessment in Climate Change Adaptation](#)

Workshops

- A series of capacity building workshops have been held in different municipalities since 2010. These include Sudbury (October 2010), Kingston (February 2011), Hearst (August 2011), Kapuskasing (October 2011), Smooth Rock Falls (October 2011), Cochrane (November 2011), and Carleton Place (February 2012).
- Expert-led technical workshops organized by the Clean Air Partnership were held in 2011 to help prepare local stakeholders for climate change impacts in urban areas. These workshops were focused on emergency management and critical infrastructure, high rise residential buildings, electricity, urban forests, and health equity.
- OCCIAR hosted four webinars on boreal forests, climate science and the importance of adaptation, communicating climate change, and the 2011 [Practitioner's Guide to Climate Change Adaptation in Ontario's Ecosystems](#).
- OCCIAR hosted two citizen panel workshops in order to gauge public understanding and opinion on Ontario's adaptation progress. Citizen panels are typically groups of 15-20 individuals who interact with experts to discuss topics of interest and provide recommendations on policy initiatives. The first workshop, held in Sudbury in 2011 on November 12-13 and November 19-20, allowed experts to communicate climate science and impacts, mitigation and adaptation strategies, and climate policy in the province. Discussion between the climate experts and citizen participants included questions about the experts' presentations and citizen concerns and values. The second workshop, held in Ottawa in

2012 on February 25-26 and March 4-5, included a brainstorming session to elicit citizen comments and recommendations, which were later presented in a final report to municipal, provincial, and federal government agencies. Experts at the workshops included representatives from the University of Waterloo, Laurentian University, Ministry of Natural Resources, Sudbury District Public Health Unit, and OCCIAR, among others.

2. Ontario Regional Adaptation Collaborative

OCCIAR is also a partner in the Ontario Regional Adaptation Collaborative. Through this funding, OCCIAR worked with partners to host two workshops and develop adaptation case studies.

Workshops

- OCCIAR and the Hamilton Conservation Authority hosted a one-day workshop in Hamilton, Ontario in June 2011. Participants included representatives from the Hamilton Conservation Authority, the City of Hamilton, and local conservation groups. The goals included providing climate science and impacts information, a background on adaptation and examples, a review of available tools to help identify risks and vulnerabilities; in addition, participants discussed the role of Conservation Authorities in adaptation.
- OCCIAR and Conservation Ontario hosted three one-day workshops with Conservation Authority staff in Kingston, London, and Hamilton in February and March 2011. The goals were to discuss climate change effects on Conservation Authorities, exchange information on climate initiatives in Conservation Authorities, and discuss opportunities and challenges for mitigation and adaptation in operations.

Case studies

OCCIAR developed two case studies on adaptation initiatives in the [City of Greater Sudbury](#) and the [Hamilton Conservation Authority](#).

3. Lake Simcoe Adaptation Planning Process

Lake Simcoe is the largest inland body of water in southern Ontario and supports a variety of wildlife and habitats and nearly 350,000 residents. The watershed has been the subject of conservation attention through the *Lake Simcoe Protection Plan*, which includes a climate change policy directing provincial entities to create a climate change adaptation strategy for the watershed. OCCIAR, along with a number of partners from the University of Waterloo, Ministry of Natural Resources, and Ministry of the Environment, undertook a planning process to develop recommendations to support the development of a Lake Simcoe adaptation strategy. The planning process began in May 2010 and included vulnerability assessments of climate change impacts on agriculture; wetlands, streams, and rivers; water quality and quantity; infrastructure; biodiversity; invasive species; natural heritage areas; species at risk; nature-based tourism and recreation; vegetation cover; and wildlife. Through workshops and consultations with experts, more than 900 recommendations were generated to support adaptation; these items were reviewed and revised into 695 recommendations that were then prioritized based on strategic planning, legislation and policy, research, monitoring, communication, and planning and management. Ninety-two of the recommendations were identified as first-order priorities, which were presented and evaluated during an April 2011 workshop; from these discussions, 30 strategies were prioritized for inclusion in the development of the adaptation plan for the Lake Simcoe Watershed (Douglas et al. 2011).

Project Outcomes and Conclusions

OCCCIAR is a major participant in building capacity for climate change adaptation in Ontario. Materials from the Community Adaptation Initiative, including reports, presentation slides, webinar recordings, and fact sheets are available on the website (http://www.climateontario.ca/p_cai.php).

References

Douglas, A.G., C. Lemieux, G. Nielsen, P.A. Gray, V. Anderson, & S. MacRitchie. (2011). *Adapting to Climate Change -- Tools and Techniques for an Adaptive Approach to Managing for Climate Change: A Case Study*. Ontario Centre for Climate Impacts and Adaptation Resources (OCCCIAR), 935 Ramsey Lake Road, Sudbury, Ontario, P3E 2C6. Unpublished Report. 66p.
<http://www.climateontario.ca/doc/workshop/2011LakeSimcoe/Lake%20Simcoe%20Adaptation%20Options%20Final%20Report%20June%20%202011.pdf>

Status

Information gathered from project contact's survey responses on June 21, 2012, ongoing personal communication, publications, and other resources.

Citation

Gregg, R. M. (2012). *The Ontario Centre for Climate Impacts and Adaptation Resources' Climate Adaptation Initiatives* [Case study on projects of the Ontario Centre for Climate Impacts and Adaptation Resources]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Conduct training and planning exercises, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Policy: Develop/implement adaptation plans

Infrastructure, Planning, and Development: Community planning (developing climate-smart communities)

*U.S. Global Change Research Program*²⁶²

By: Rachel M. Gregg

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Project Summary/Overview

The U.S. Global Change Research Program's mission is "to build a knowledge base that informs human responses to climate and global change through coordinated and integrated federal programs of research, education, communication, and decision support." The Program produces assessments of climate change and its implications, participates in the U.S. Interagency Climate Change Adaptation Task Force, and provides educational materials to support climate literacy and educational development.

Project Background

The U.S. Global Change Research Program (USGCRP) was established with the passage of the Global Change Research Act in 1990. The USGCRP is charged with coordinating scientific research within the Federal Government on global change and its potential implications for natural environments and communities. Federal departments and agencies that participate in the USGCRP include:

- Department of Commerce
- Department of Defense
- Department of Energy
- Department of the Interior
- Department of State
- Department of Transportation
- Department of Health and Human Services
- Department of Agriculture
- National Aeronautics and Space Administration
- National Science Foundation
- Smithsonian Institution
- Agency for International Development
- Environmental Protection Agency

Members from each of the aforementioned departments and agencies are on the Subcommittee on Global Change Research within the National Science and Technology Council.

Project Implementation

The USGCRP provides assessment and educational materials for use by the public and private sectors.

²⁶² Also available at <http://www.cakex.org/case-studies/2761>

Assessments

As part of its mandate, the USGCRP produces global change impacts assessments every four years. The first – *National Assessment of the Potential Consequences of Climate Variability and Change in the United States* – was completed in 2000. The most recent – *State of the Knowledge Report of Global Climate Change Impacts in the U.S.* – was released in 2009. These assessments include impacts by geographic region and economic sectors.

In addition, the USGCRP led the production of the U.S. Climate Change Science Program’s 21 Synthesis and Assessment Products (SAPs), released between 2004 and 2009, concerning climate trends, impacts, and management options. The SAPs concerned with climate change adaptation include:

- SAP 4.1 - Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region
- SAP 4.2 – Thresholds of Climate Change in Ecosystems
- SAP 4.3 - The Effects of Climate Change on Agriculture, Land Resources, Water Resources and Biodiversity
- SAP 4.4 – Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources
- SAP 4.5 – Effects of Climate Change on Energy Production and Use in the United States
- SAP 4.6 - Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems
- SAP 4.7 – Impacts of Climate Variability and Change on Transportation Systems and Infrastructure

Educational Materials

The USGCRP created the *Climate Change, Wildlife, and Wildlands Toolkit for Formal and Informal Educators* in order to aid educators in communicating how climate change will affect the environment and how people can become “climate stewards.” The 2009 version of the Toolkit contains background information on climate change science, a video on projected climate impacts on wildlife and habitats, and 11 case studies in eco-regions throughout the U.S. containing regional impacts and adaptation strategies. The eco-regions include: Western Forests and Mountains, Western Coastline, Eastern Coastline, Gulf Coast, Pacific Islands, Caribbean, Great Lakes, Eastern Forests and Woodlands, Polar/Subpolar, Desert Arid, and Prairie Grasslands.

The USGCRP also released a guide called *Climate Literacy: The Essential Principles of Climate Science*, which contains details on climate change science and impacts and mitigation and adaptation strategies. The guide was developed through collaboration between federal agencies and non-governmental organizations.

Project Outcomes and Conclusions

The USGCRP is mandated to coordinate federal research on climate change and to assess global change in national assessments; the next [National Climate Assessment](#) is expected in 2013. The USGCRP is also engaged in the development of a national climate change adaptation strategy as part of the U.S. Interagency Climate Change Adaptation Task Force.

References

National Assessment of the Potential Consequences of Climate Variability and Change in the United States (2000): <http://www.globalchange.gov/publications/reports/scientific-assessments/first-national-assessment>

State of the knowledge report of Global Climate Change Impacts in the U.S. (2009):
<http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts>

Status

Information gathered from publications and other resources.

Citation

Gregg, R. M. (2010). *U.S. Global Change Research Program* [Case study on a project of the U.S. Global Change Research Program]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Increase/Improve public awareness, education, and outreach efforts, Conduct research, studies, and assessments

*Understanding and Modeling the Impacts of Human Behavior and Climate Change on the
Maumee River Watershed, Ohio*

By: Jessi Kershner

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Project Summary/Overview

The Maumee River watershed, located in western Ohio, is the largest watershed in the Great Lakes region. Due to multiple sources of pollution including agricultural runoff, combined sewer overflows, and other non-point sources, the health of both the river and Lake Erie are suffering, resulting in reduced fish populations and more harmful algal blooms. Predicted climate change impacts such as heavier and more frequent rainfalls will likely exacerbate existing problems. In response, researchers at Ohio State University and Case Western Reserve University have initiated a project exploring how people's behaviors upstream can offset negative impacts of current and future conditions and preserve important ecosystem services provided by the lake. They also plan to develop land use models to assess the impacts of climate change on agricultural practices and forecast how behaviors may change under future conditions.

Project Background

The Maumee River watershed, located in western Ohio, is the largest watershed in the Great Lakes basin covering over 8,300 square miles. A large portion of the watershed has been designated as an Area of Concern due to substantial agricultural runoff and other non-point source pollution as well as old dumps and contaminated industrial sites, combined sewer overflows, and disposed dredged materials (EPA 2012). Agricultural and the other land use practices lead to increased runoff of nutrients (e.g., phosphorous) and sediment downstream into Lake Erie, potentially resulting in reduced water clarity, increased incidents of harmful algal blooms, and a loss of high-value fish populations. A large part of the economy in the Maumee River watershed relies on ecosystem services provided by the lake including tourism, fisheries, industrial, and recreational opportunities, which are threatened by these impacts. Watershed restoration work has been underway for over 20 years to return the watershed to fishable and swimmable condition, although work still remains to repair habitats.

Predicted climate changes in the Great Lakes region including increasing air temperature and precipitation and decreasing ice coverage are likely to alter river discharge patterns, increase soil erosion, and increase both the sediment loads of the river and river scour on bed and banks. These impacts will wash more nutrients and sediments from upstream areas of the watershed downstream into Lake Erie, compounding existing problems. In response to current and future threats for the Maumee River watershed, researchers at Ohio State University and Case Western Reserve University received National Science Foundation funding for a 4-year project to examine how land use

practices in the watershed affect the water quality of Lake Erie and how people's perceptions of the lake influence those practices. As part of this project, researchers plan to develop decision-making models to increase understanding among policy makers and watershed managers about how guidelines and regulations are formed, and identify upstream practices that improve the downstream ecosystem. The researchers also plan to incorporate multiple climate scenarios to assess the potential impacts on agricultural practices and forecast how behaviors may change under new conditions.

Project Implementation

The first phase of the project includes focus groups and the development of a decision-making model to determine the link between people's perception of Lake Erie, how that perception impacts lake health, and how lake health in turn influences people's perceptions. For the focus groups, researchers plan to interview different groups of people (e.g., agricultural and urban populations) living within the Maumee River watershed. To further understand what factors are driving people's decisions, how regulations are made, and how actual decisions are made by people on the ground researchers plan to hold workshops and interviews with scientific experts, watershed managers, and government officials as well as survey the general population. From these activities, they hope to develop a model that predicts how people are likely to respond to a given set of conditions. Following this broader survey of populations within the watershed, researchers plan to focus specifically on farmers, their agricultural practices, and what influences their land management decisions.

The second phase of the project will focus on the development of land use models. These models are likely to be based on traditional methods that consider past developments as well as the new models on people's behaviors, and will include hydrologic models to examine how water flows in the watershed. Models will also include different climate change scenarios such as increased rainfall and warmer temperatures to allow researchers to examine the potential impacts on agricultural practices, people's perceptions of lake health, and how behaviors may change as future conditions change.

Project Outcomes and Conclusions

The ultimate goal of this work is to build a model that can be used to predict future farmer behavior as the climate and economy change, with the hope of limiting agricultural runoff into the watershed to prevent harmful algal blooms and other negative impacts to the ecosystem. The results of this project will be used to help increase understanding about how climate change is going to impact the local system - both ecological and social - and to identify ways in which the water quality of western Lake Erie can be improved to maintain ecosystems services that people depend on.

References

- Dierkes, C. (2011). *How's the Lake Doing?* <http://ohioseagrant.osu.edu/maumeebay/docs/feature-howisthelake.pdf>
- Environmental Protection Agency (EPA). (2012). Great Lakes Areas of Concern: Maumee River. <http://www.epa.gov/glnpo/aoc/maumee.html>

Status

Information gathered from personal communication, publications, and other resources. Case study reviewed by project lead.

Citation

Kershner, J. M. (2012). *Understanding and Modeling the Impacts of Human Behavior and Climate Change on the Maumee River Watershed, Ohio* [Case study on a project of Ohio State University]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Increase/improve public awareness, education, and outreach efforts, Conduct research, studies, and assessments, Conduct training and planning exercises, Create/enhance resources and tools

Natural Resource Management and Conservation: Reduce non-climate stressors likely to interact with climate change

Using Green Infrastructure to Prevent Sewage Overflows in Detroit

By: Jessi Kershner

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Project Summary/Overview

In the Great Lakes region, climate change is predicted to bring greater amounts of precipitation falling in shorter periods of time, resulting in increased flooding. For Detroit, flooding brings an extra problem – sewage overflows. This realization inspired the Sierra Club Great Lakes Program to get involved in the sewer overflow issue and begin exploring green infrastructure solutions. Green infrastructure creates rainwater filtration right at the surface, keeping rainwater from entering the combined sewer system and preventing additional sewage pollution in the Great Lakes. This case study is also part of a [Climate Adaptation Toolkit](#), developed in partnership between EcoAdapt and Freshwater Future.²⁶³

Project Background

The Metro Detroit area of Michigan covers close to 4,000 square miles of land and is home to over 4.2 million people. The city itself is located on the Detroit River, a 32-mile long river connecting Lake St. Clair to Lake Erie. The Detroit Water and Sewerage Department (DWSD) is the third largest water and sewer utility in the U.S., and provides water service to 3 million people in 126 neighboring counties in Southeastern Michigan. DWSD's Wastewater Treatment Plant is the largest single-site wastewater treatment facility in the U.S., and currently services the needs of 35% of the state's population – including all of Detroit and 76 other surrounding communities. DWSD is a combined sewer system, which means that sewage and stormwater runoff run through a single pipe system, and anything more than an inch of rain in a short period of time can cause raw sewage to overflow into rivers and streams.

In the Great Lakes region, climate change is predicted to bring more intense storms including greater amounts of precipitation during shorter time periods. More intense rainfall in a shorter period of time is likely to result in more sewage overflow events, adding more sewage pollution to the Great Lakes. In response, the Sierra Club Great Lakes Program began investigating solutions that would address the sewage pollution problem and help prepare communities for climate change. Early on, the Sierra Club realized that getting DWSD to invest in state-of-the-art technology to improve their wastewater treatment plant would solve many of the issues, but it would likely raise the costs of water and sewage for residents. Many Detroit residents were hit hard by the declining economy, making this a less-than-ideal solution.

Instead, the Sierra Club decided to focus on green infrastructure solutions that create rainwater filtration at the surface rather than in the sewer systems. This approach is often cheaper than

²⁶³ <http://www.freshwaterfuture.org/resources/climate/climate-adaptation-toolkit.html>

traditional infrastructure options, help beautify the community, and provide opportunities for community engagement and empowerment. Green infrastructure includes everything from rain barrels and cisterns to rain gardens and constructed wetlands to landscaping with native vegetation and using permeable pavers. Rain barrels and cisterns collect rainwater from downspouts on homes or businesses, keeping it out of the sewers and providing water that can be used to water gardens or lawns, wash cars, and other such uses. Rain gardens, native vegetation landscaping, constructed wetlands, and permeable pavers allow rainwater to filter through the soil rather than flooding parking lots and roads and carrying polluted runoff into the sewer system.

Project Implementation

To raise awareness and spur implementation of green infrastructure the Sierra Club has been focused on education and outreach throughout Detroit, talking to residents and community groups about the benefits and cost-effectiveness of green infrastructure. In partnership with Freshwater Future, they held a mini-conference to educate community groups about climate change adaptation strategies and green infrastructure. One group, the West Grant Boulevard Collaborative, received a grant from Freshwater Future to create rain gardens at a branch of the Detroit Public Library. They designed the rain garden around a low area in order to collect rainwater and allow it to slowly percolate into the soils, and they planted hardy native vegetation that can tolerate variations in wet and dry conditions, stabilize soils, and absorb and filter polluted rainwater. In Fall 2011, the Sierra Club installed a rain garden in another Detroit neighborhood, which received a very positive response from the neighbors. As a result, they have expanded their efforts and have planted 5 more rain gardens on the block with 2 additional gardens on the way. Funding from the Erb Valley Foundation and Freshwater Future has been used to purchase plants and provide technical assistance on how, where, and what to plant in the rain gardens.

In Summer 2011, the Sierra Club started offering rain garden tours in different Detroit communities, which led to the creation of an 8-step rain garden guide that talks about climate change, increased precipitation, Detroit's combined sewer system, and what residents can do about it. They partnered with a business, Backstreet Container, to acquire old pepper barrels that were distributed to residents for use as rain barrels, and partnered with a local bike store, Wheelhouse Detroit, to do two bike tours – called the Detroit Green Water Infrastructure Bike Tours – that sold out. Participants went on a 12-mile ride to learn about rainwater, Detroit's combined sewer system, and to see some of the green infrastructure solutions that exist to help prevent flooding and sewage pollution. During one of the tours it was raining, giving the participants a chance to see the green infrastructure in action.

In addition to their education and outreach efforts, the Sierra Club now co-chairs a Water Subcommittee for the Detroit City Council Green Taskforce, initiated a home water audit program, and began collaborating with the Peoples Water Board Coalition. Through the Water Subcommittee effort, they have encouraged the city to develop a watershed plan and they have created the Detroit Water Agenda, which looks at best management practices for stormwater and how that relates to climate change. The group is now working to prioritize recommendations from the Water Agenda to begin implementation. Their home water audit program teaches people how to save water and money by using green infrastructure and encourages people to refrain from doing laundry and other water-intensive activities when it's raining heavily. Sierra Club has also collected over 1000 signatures requesting that the DWSD create an incentive program for residents and businesses that do install green infrastructure. Finally, they are collaborating with the Peoples Water Board Coalition – a social justice group – to talk about concerns of aging infrastructure, climate change, keeping water affordable, and creating jobs.

Project Outcomes and Conclusions

This approach to education and engagement—not just bringing the issue down to the local level, but giving people both problems and solutions they can observe in their own neighborhoods—seems to be garnering a lot of support. Next steps for the Sierra Club include working with a local non-profit, Data Driven Detroit, to start mapping sewage outfalls on the Detroit and Rouge rivers to identify more strategic places to install green infrastructure. The Sierra Club is also exploring the potential for some type of backwards calculation that helps determine how many rain gardens or constructed wetlands would be needed to reduce the overall amount of sewage going into the rivers.

References

Detroit Water and Sewerage Department http://www.dwsd.org/pages_n/about_dwsd.html

Status

Information gathered from interviews with project contact on October 19, 2011 and October 16, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Kershner, J. M. (2012). *Using Green Infrastructure to Prevent Sewage Overflows in Detroit* [Case study on a project of the Sierra Club Great Lakes Program – Michigan]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Increase/improve public awareness, education, and outreach efforts, Conduct training and planning exercises

Infrastructure, Planning, and Development: Community planning (developing climate-smart communities), Create or modify shoreline management measures

Water Supply Planning for Illinois

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Project Summary/Overview

The Illinois State Water Survey, in collaboration with the Illinois Department of Natural Resources' Office of Water Resources and the Illinois State Geological Survey, examined historical climate information and future climate scenarios in order to improve the understanding of and planning for the effects of climate change on supply and demand of regional water resources. The project examined climate impacts (e.g., temperature, precipitation) on surface and groundwater resources and resulting complications for sustainable water supply planning in the state.

Project Background

Approximately 16 billion gallons of water are used every day in Illinois; about 85% is used for domestic electric power production, most of which is recycled. The remaining 15% (~2 billion gallons) is withdrawn and consumed by state residents. The water supply/demand issue is prevalent in the state with an ever-expanding population and increasing demand for water. Planners and managers must deal with a variety of challenges, including the quality, availability, and demand of water and how these are affected by events such as droughts, flooding, and climate change. Climate impacts of concern to water resources in the state include changes in temperature and precipitation patterns, which can cause secondary effects on water supply and demand.

In 2006, former Governor Rod Blagojevich issued Executive Order 2006-01 requiring the state to develop and implement regional water supply plans. Through a three-year funded program, the Illinois State Water Survey worked with partners to pilot water supply planning in two regions – East Central Illinois and Northeastern Illinois. The program's goals were to assess water resource availability and to evaluate the impacts of climate change on the ability to meet future water demands. Project staff examined water availability, demand, and cost under projected population changes and different climate scenarios.

Project Implementation

The project began by looking at two priority watershed regions: Northeastern Illinois and East Central Illinois. The focus in Northeastern Illinois was on the Fox River watershed and the Deep Bed aquifer system. The focus in East Central Illinois was on the Mahomet aquifer system and the Sangamon River watershed. The primary program partners – the Illinois State Water Survey, Illinois State Geological Survey, and the Illinois Department of Natural Resources' Office of Water Resources – collaborated to provide technical support to the two regional planning groups and developed models to support the evaluation of water management strategies to meet changing water resources needs through 2050.

Planning groups were formed and led by different entities in the pilot regions. In the [Northeastern Illinois pilot area](#), the Chicago Metropolitan Agency for Planning led the Regional Water Supply Planning Group (RWSPG) (Meyer et al. 2012); in the [East Central Illinois pilot area](#), the Mahomet Aquifer Consortium led the Regional Water Supply Planning Committee (RWSPC) (Roadcap et al. 2011). Both the RWSPG and the RWSPC were responsible for developing water supply planning and management guidelines with support from the primary program partners. The partners worked to examine and understand water supply and demand over a 50-year time period in order to develop materials to support decision making, planning, and management of water resources in changing socioeconomic and climatic conditions. They examined water withdrawals and uses, assessed future temperature and precipitation conditions for Illinois using publicly available GCMs, incorporated those conditions into surface water and groundwater models for the regions, and evaluated needed changes to existing water resources policies and regulations, following the Illinois State Water Survey's framework (Winstanley et al. 2006).

Project Outcomes and Conclusions

Through this program staff were able to analyze the state's water supply systems and projected climate change impacts and provide recommendations to improve resilience. Key steps to support sustainable water supply planning were identified, such as evaluating existing facilities to cope with drought conditions and building historic drought and climatic data into water supply scenarios to enhance the resilience of infrastructure. Before the project was initiated, state water planning activities were often fragmented; this effort aimed to increase dialogue and coordination, and allowed managers to look at the cumulative impacts of use and management response strategies on water resources.

Regional planning is currently underway in three [Priority Water Quantity Planning Areas](#) – East Central Illinois, Northeastern Illinois, and the Kaskaskia Region in southwestern Illinois. The RWSPG and the RWSPC groups continue to work to coordinate community and stakeholder involvement to achieve water supply sustainability.

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www.isws.illinois.edu/iswsdocs/wcwbil/WaterCycleandWaterBudgetsinIL.pdf

Status

Information gathered from project contact's survey responses on June 20, 2012, publications, and other resources.

Citation

Gregg, R. M. & Hitt, J. L. (2012). *Water Supply Planning for Illinois* [Case study on a project of the Illinois State Water Survey]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Increase/improve public awareness, education, and outreach efforts, Conduct research, studies, and assessments

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change

Weather–Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study

By: Jessica Hitt

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Project Summary/Overview

Climate change projections show an increase in the frequency and severity of storms across Minnesota; the resulting increase in runoff and flow may overwhelm the region’s existing stormwater management systems. This project aims to assist regional managers in the Minnehaha Creek watershed cope with uncertainty from climate projections and identify ways to adapt stormwater systems to future conditions. The project includes two study sites in the cities of Minneapolis and Victoria.

Project Background

The Weather – Extreme Trends (WET) project is the fourth in a series of projects by Syntectic International LCC and Antioch University New England (NE) focused on preparing local communities for extreme weather events. The local project leader is the Minnehaha Creek Watershed District (MCWD). The WET project aims to facilitate a stakeholder-driven adaptation planning process that will build the capacity of regional decision makers and prepare the watershed and communities for projected climate change impacts.

With 129 lakes, eight major creeks, and thousands of wetlands, the watershed is rich in water resources; regional managers have not historically focused on the quantity and availability of water. The region has seen an increase in both the severity and frequency of storm events; as a result, the stormwater facilities of regional cities and municipalities are being overwhelmed by these events. Events such as the flooding in Duluth during July 2012 are convincing managers and planners that they may be ill prepared for the projected near-term climate future. The project, funded by the National Oceanic and Atmospheric Administration, will run from spring 2012 to summer 2013. The project’s two pilot communities, the cities of Minneapolis and Victoria, were selected because they represent regional examples of the problems city managers and planners are facing and examples of ways to start integrating climate change into decision-making processes. The WET’s two main goals are to promote a regional stakeholder adaptation planning process and to provide the stakeholder group with the data and information needed to make informed adaptation decisions.

Historically water management facilities have been built and regulated by policies based on the assumption of stationarity and the theory that the region’s natural systems would continue to function normally under relatively stable conditions. However, recent climate trends and projected impacts show that these historical assumptions will not be effective to manage the changing conditions of the future. The technical partners of the project at Syntectic International, Antioch

University NE, University of Minnesota, and Stratus Consulting are completing an analysis of stormwater management systems for the project's two pilot cities. This includes modeling the systems' ability to convey projected peak flows, modeling water quality impacts from projected land use and precipitation changes, and conducting a cost-benefit analysis of recommended adaptation improvements. While modeling efforts are focused on the two pilot cities, they are also being broadly extrapolated to other communities within the watershed as well.

The MCWD is leading the outreach and information dissemination piece of the project with Antioch University NE and aims to create an involved stakeholder-driven decision making process, build regional planners' capacity, and support decision makers as they work to design and implement adaptation plans.

Project Implementation

The WET project coalition is a large group of organizations that are donating in-kind staff time and collaborating on various aspects of the project to make it a success. The project's research and technical components are being spearheaded by Syntectic International and Antioch University NE, along with contributions from the University of Minnesota and Stratus Consulting. The project's outreach component is being led by the MCWD and Antioch University NE; other partners include the cities of Victoria and Minneapolis. Both the outreach and research and technical components of the project are occurring simultaneously.

The MCWD plans to host three stakeholder forums over the grant period to facilitate the adaptation planning process. The first forum, aimed at increasing awareness and assessing where regional planners currently are in terms of climate change knowledge, was held in May 2012 and attracted 59 planners, officials, engineers, and managers. The forum focused on introducing attendees to regional current and historical climate information, extreme weather events and their implications, and taking stock of participants' understanding and perceptions of climate change and adaptation. During the forum, participants broke up into small groups to discuss extreme weather events and adaptation planning. Through the discussions, participants identified priorities, information and resource needs, barriers, and roadblocks that need more investigation to better prepare the group to develop adaptation plans. The top discussion items were used to develop themes for four working groups – Education/Outreach, Land Use Policy and Planning, Stormwater Infrastructure and Low Impact Development, and Sustainable Funding for Stormwater Management; these groups plan to meet periodically and report back during the second forum to share strategies and actions developed.

In winter 2013, the second forum will introduce the technical team's findings to the larger stakeholder group and will begin to move participants through an adaptation planning process. Workshops will also be held in the pilot communities in spring 2013 to get buy-in from local decision makers and begin looking at how project data and information can be applied locally to develop adaptation strategies. The third forum – A Regional Stormwater Adaptation Symposium – is planned for summer 2013 and will be the largest of the three forums. Its focus will be to inform the greater region about the project, results, planning process, and most importantly how the project methodology can be applied to other local municipalities.

Project Outcomes and Conclusions

While the project is regionally focused, the two pilot cities, Minneapolis and Victoria, were selected because they are representative of other regional and statewide communities and municipalities. The

goal of using Minneapolis, a fully developed city, and Victoria, a developing city, as pilot sites was to allow other communities grappling with similar issues and impacts to be able to look to the WET project as a model case study. The models developed and data gathered are intended to support similar efforts by regional practitioners.

In order to measure success, the project team plans to evaluate all stakeholder and outreach efforts both qualitatively and quantitatively. After the first forum, the MCWD handed out a quick three-question survey to gather participant feedback on the clarity and usefulness of information presented as well as suggestions for improvement.

Planned next steps beyond the grant period include implementing and evaluating the adaptation strategies developed throughout the planning process.

Status

Information gathered from interview with Mallory Anderson on July 24, 2012, publications, and other resources. Case study reviewed by interviewee.

Citation

Hitt, J. L. (2012). *Weather – Extreme Trends (WET): The Minnehaha Creek Watershed Stormwater Adaptation Study* [Case study on a project of the Minnehaha Creek Watershed District]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Increase/improve public awareness, education, and outreach efforts, Conduct research, studies, and assessments, Conduct training and planning exercises

Policy: Develop/implement adaptation plans

Infrastructure, Planning, and Development: Make infrastructure resistant or resilient to climate change

Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies

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Project Summary/Overview

The Wisconsin Initiative on Climate Change Impacts (WICCI) was created to support the efforts of multiple stakeholders charged with identifying vulnerabilities to climate change and developing adaptation strategies. WICCI released an impacts and adaptation strategies assessment in 2011 as a first step toward developing a statewide climate change adaptation strategy.

Project Background

Climate change in Wisconsin is expected to cause increasing air temperatures, altered precipitation patterns, and increasing extreme weather events and storms. By mid-century, average annual temperatures statewide are expected to be 6-7°F higher with more precipitation in winter, spring, and fall, and more frequent storms in spring and fall (WICCI 2011). These impacts will have secondary effects, including decreased ice cover, shifting plant hardiness zones, and increasing water temperatures, among others. Climate change may have both positive and negative effects; for example, the agricultural sector may benefit from a longer growing season with warmer temperatures in spring and fall, but higher temperatures in the summer could reduce crop yields of corn and soybeans (WICCI 2011).

WICCI was created in 2007 by a group of stakeholders from the Wisconsin Department of Natural Resources (WDNR) and the University of Wisconsin-Madison (UW-Madison) concerned about climate change effects on the state's people and the natural environment. Climate scientists from UW-Madison were planning on downscaling data for the state based on the models made available by the Intergovernmental Panel on Climate Change (IPCC), but realized that they needed a better understanding of how their products could best serve those who manage the state's natural resources, the built environment, and health-related issues. Scientists from WDNR and UW-Madison gathered in the summer of 2007 to discuss potential means for collaboration, and further meetings with other interested parties (e.g., businesses, non-profit entities) resulted in the structure that became WICCI.

Project Implementation

WICCI is supported by a Science Council, an Operations and Outreach Unit, an Advisory Committee, and Working Groups. The Science Council, composed of representatives from UW,

WDNR, and other entities, governs WICCI; the Council is responsible for identifying scientific issues of concern, potential funding sources, and endorsing the Working Groups' findings. An Operations and Outreach Unit based out of UW-Madison provides support to the Council and conducts outreach for WICCI, while an Advisory Committee composed of representatives from different governmental and non-governmental organizations provides resources and knowledge to support WICCI's mission. The Working Groups are charged with providing the expertise needed to assess impacts on specific sectors or geographies and to develop adaptation recommendations; the groups are topic-based (Climate, Adaptation), place-based (Green Bay, Milwaukee), and sector-based (Agriculture, Central Sands Hydrology, Coastal Communities, Coldwater Fish and Fisheries, Forestry, Human Health, Plants and Natural Communities, Soil Conservation, Stormwater, Water Resources, Wildlife). Each group is led by two co-chairs and has its own set of goals and objectives.

WICCI released a full assessment of both climate change impacts and adaptation strategies in 2011 (WICCI 2011). Individual assessments were provided by the 15 working groups set to inform this report; these individual reports are available on the [WICCI website](#).

WICCI received a grant from the Ira and Ineva Reilly Baldwin Wisconsin Idea Endowment, which supported the project kickoff and report production.

Project Outcomes and Conclusions

Looking to the future, WICCI is working to establish more Working Groups that are place-based, such as the Driftless Area in southwestern Wisconsin and the Northwoods in northern Wisconsin, and other issues, including Economics and Community Adaptation Planning. WICCI continues to conduct outreach to as many groups as possible, including K-12 educators, all 600 of the University of Wisconsin-Extension agents, and specific interest groups. In March 2012, WICCI conducted three workshops with about 120 DNR managers to present the findings of the working group reports, and to encourage participants to incorporate climate change into strategic planning.

Although WICCI is widely touted as a model structure for other states and groups to emulate, its major burden has been funding. While the scientists have been successful in garnering funding for research, funding for organizational support has proved more challenging.

References

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Status

Information gathered from interview with project contact on May 16, 2012, publications, and other resources. Case study reviewed by project contact.

Citation

Gregg, R. M. (2012). *Wisconsin Initiative on Climate Change Impacts: A Bottom-Up Approach to Developing Climate Change Adaptation Strategies* [Case study on a project of the Wisconsin Initiative on Climate Change Impacts]. Product of EcoAdapt's [State of Adaptation Program](#) (Last updated October 2012)

Type of Adaptation Action/Strategy

Capacity Building: Design or reform institutions, Conduct research, studies, and assessments, Increase/improve public awareness, education, and outreach efforts, Create/enhance resources and tools

Policy: Develop/implement adaptation plans