



Improving the Odds:

Using Climate-Readiness Planning to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem

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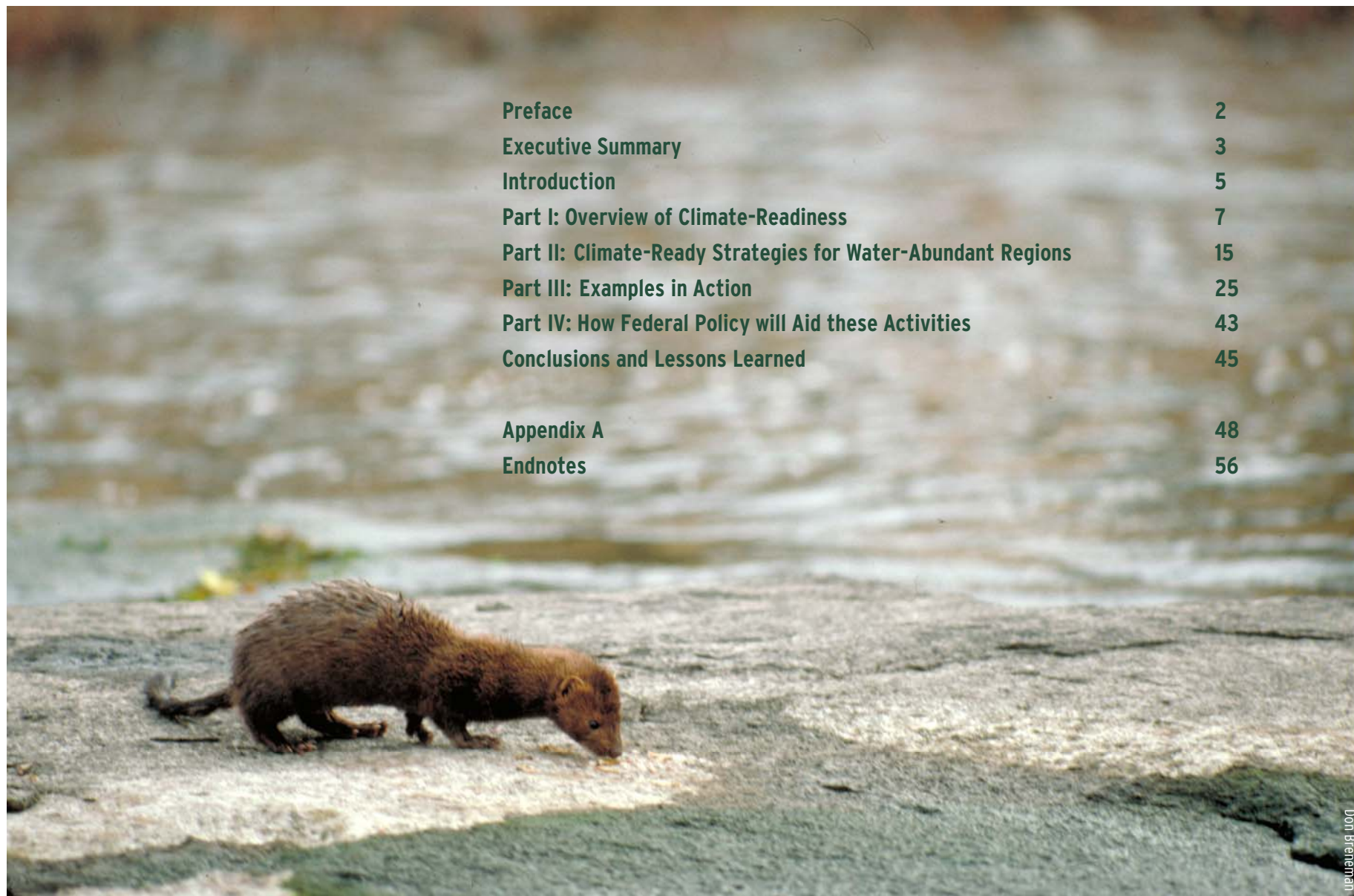
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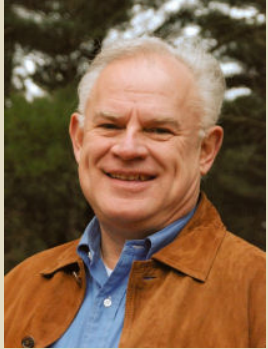
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Don Brennan

Preface



world, and summer memories for those who delight in their shores.

My experiences with the Great Lakes go back to the 1960s when, on a family vacation at Lake Erie, I learned that in spite of how beautiful those vast waters looked on the surface, largely-invisible pollution was destroying the lake and the fish that lived in it.

This crisis in Lake Erie and other Great Lakes sparked myself and a generation of individuals to commit to a healthy Great Lakes. Thankfully, due to the work and determination of thousands, the Great Lakes have improved since then. Among other victories, Lake Erie, once declared dead, now boasts a world class fishery. Lake water levels are now protected by the

The Great Lakes provide so many things -- 20% of the earth's fresh water, a defining sense of place for over 35 million people, an economy that is the fifth largest in the

Great Lakes Water Resources Compact. And the Great Lakes Restoration Initiative is providing much-needed ecological and economic restoration.

However, there are still significant threats to the future health and productivity of the Great Lakes and still much work to do. Dangerous Asian carp are closer than ever to dominating aquatic life. Agricultural and industrial pollution still upsets the health of the lakes. Pressure from water demands is still increasing. And climate change has the ability to intensify these and all of the challenges that affect the stability of the Great Lakes.

The impacts of climate change are already being felt. Warmer temperatures, less lake ice, impaired wildlife, and extreme precipitation events resulting from climate change are becoming part of the Great Lakes story. We cannot continue to let these changes affect the quality and supply of our freshwater and change the identity of the Great Lakes. That is why we must safeguard the Great Lakes against climate change impacts and why the most important thing we can to secure the legacy of a healthy Great Lakes for future generations is to halt climate change pollution.

This report provides a look at how we can think about and begin to take action to safeguard this precious

resource from the changes in climate that have already occurred and those that we know are coming in the future. It describes barriers and opportunities, as well as examples of safeguarding work in action throughout the region.

We hope this report inspires legislators, city officials, business leaders, and resource managers to work together to safeguard the Great Lakes against the impacts of climate change and enact a national, comprehensive clean energy plan that addresses climate change pollution and provides resources to help the Great Lakes.

Without decisive action to reduce climate change pollution and defend the water and wildlife of the Great Lakes from climate change impacts, all the progress made to restore this ecosystem could be lost. We owe it to our children and grandchildren to act now to protect and sustain these magnificent treasures, the Great Lakes.

A handwritten signature in black ink, appearing to read 'Larry Schweiger', with a long, sweeping horizontal line extending to the right.

Larry Schweiger
President and CEO

There have been many successes in Great Lakes restoration and protection recently. President Obama has committed \$5 billion over five years, with \$475 million committed by Congress in the first year, to fund regional ecological restoration activities. A process is underway to update the Great Lakes Water Quality Agreement. The Great Lakes Water Compact provides a mechanism to protect water levels from overwithdrawal. The potential for a sustained stream of money to fight invasive species, clean up toxic hot spots and address restoration priorities through this year's introduction of the Great Lakes Ecosystem Protection Act.

As we celebrate these successes we must also look toward the future. Over the past few decades, we have measured documented environmental changes such as thinning of lake ice, migration of species northward, extreme flooding, and warmer air temperatures on record. Left unabated, changes to our climate and environment could compromise the work we have done.

As demonstrated in this report, being ready for and coping with the inevitable effects of climate change—an endeavor referred to as climate change adaptation or climate-readiness—is emerging as the next step for Great Lakes protection.

To provide the best possible chance for conserving these resources in a rapidly changing climate and in the context of other stressors, it is essential that managers, planners, and policy makers have the ability to both identify what we need to do differently in the future, as well as which existing strategies and activities continue to make sense from a climate adaptation perspective.

This report, *Improving the Odds: Using Climate-Readiness Planning to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem*, features current climate-ready practices, policies, and tools that help build adaptive capacity and lead

the way for adaptation. The journey takes you through the Apostle Islands National Park, Ottawa National Wildlife Refuge, the city of Milwaukee, Wisconsin, Michigan's wildlife, and the biodiverse Lake Ontario.

What does climate-readiness look like?

This report describes and analyzes climate-readiness initiatives in the Great Lakes. Some of these initiatives are already being implemented on the ground and in the water; others are in the planning or research phases. Leading examples include:

Restoration Practices Reduce Climate Impacts

Restoration practices are an active commitment to protecting the lakes from global warming.

CLIMATE-READY RESTORATION PRACTICES:

Environmental NGOs and Restoration Experts

Identifying and implementing restoration solutions that are climate-ready will help us gain the best return on investment for Great Lakes restoration. The GLRI's \$475 million for restoration projects in 2010 provides real money for climate adaptation as part of Great Lakes restoration efforts. Here, adaptation means looking forward and using the best science, including climate science, when designing and conducting restoration projects. Freshwater Future, a non-profit who provides assistance to citizens and grassroots watershed restoration groups throughout the Great Lakes basin and the National Wildlife Federation's (NWF) Great Lakes Regional Center are partnering to work with those doing on-the-ground restoration projects. Part of this work will include efforts to inform and develop ways to make their practices climate-ready. These efforts will include collaborative workshops and the communication of 'actionable' science.

Some examples of climate-ready restoration practices that Freshwater Future and NWF will advise groups to put into practice include:

- Planting shady vegetation to reduce water temperatures
- Temporarily adding water to extend species' natural adaptation time
- Creating berms or hills for organisms to take shelter during high velocity stream flows
- Broadening species diversity to increase system resilience to change
- Identifying species or ecosystems most at risk for climate impacts.

Coordination Helps Develop, Advise and Implement Climate-Ready Strategies

Integrated and coordinated efforts to ensure transparency and accountability in achieving science-based goals are especially important under climate change.

BRIDGING CLIMATE ADAPTATION SCIENCE AND POLICY FOR REGIONAL STAKEHOLDERS:

Great Lakes Regional Integrated Sciences and Assessment (RISA)

The RISA program is funded by the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office. RISAs support the scientists who address complex climate-related issues that are of particular concern to regional resource managers and policy planners. While there are several nation-wide, there was no RISA team in the Great Lakes region until this year.

The Great Lakes RISA is innovative in that it is designed around a flexible research program that includes the input and deliberation from both scientists and regional stakeholders. An archive of climate projections and best practices for the Great Lakes region will aid in their planning and evaluation processes.

Challenges and Opportunities

Stakeholders throughout the region are beginning to get the plans in place and collaborations necessary to incorporate climate change into their various activities. These activities will not only protect our natural systems from the impacts of climate change, but also our infrastructure, our public health, and our freshwater way of life.

This report identifies opportunities for effective climate-ready action. These include:

- Taking adaptation from the planning stage to on-the-ground action. One way to act on-the-ground is via “climate-smart” restoration practices.
- Funding sources for effective adaptation and/or innovative ways to budget that allow for adaptation.
- Integrate climate change into all issues and sectors and weave it into everything we do.
- Investing in climate change education and adaptation knowledge sharing. Perhaps knowledge sharing could be a role of or by the U.S. Interagency Adaptation Task Force.

We can and we will do this together. Planning for climate change is much easier and less expensive than suffering from the disasters we will see if we take no action. With an educated public and informed leaders, the Great Lakes and the people and wildlife who depend on them will be ready for climate change.

We are already experiencing the effects of climate change on the Great Lakes. Air and lake temperatures are warming. The timing of seasonal events is changing. Wildlife species are migrating northward. Our hydrologic cycle is becoming more extreme, including heavier precipitation and more severe droughts. It is increasingly difficult to predict lake water levels based on historical trends alone.

Simultaneously, pressure on the region is mounting as demand for our resources increases.¹ Population and economic growth in other regions, including those expected to be hit hardest by climate change impacts, will put even more demand on already stressed water resources. In California, for example, the state's population is expected to double or triple over the next century, which is likely to increase water use.² The Colorado River Basin already has high demand relative to supply.³ Under predicted climate change conditions, total water system demands are expected to exceed system supply, presenting a need for substantial supplemental resources.

Cutting greenhouse gas emissions is a crucial step, but not the only step toward protecting ourselves from climate change. According to the Intergovernmental Panel on Climate Change (IPCC), even if we were to stabilize greenhouse gases at current levels surface air temperatures worldwide would continue to warm. Scientists show that current carbon emissions will remain in the atmosphere for about 50 decades.⁴

The U.S. Global Change Research Program says that if greenhouse gas emissions continue increasing unabated, the Great Lakes region could undergo warming at the rate of 1°F per decade. By 2020, for example, summers in Michigan could feel more like summers in Indiana.⁵

Natural and human history tells us that the ability of people, wildlife, ecosystems, and civilizations to adapt to a changing climate is largely dependent upon how much and how rapidly the changes occur. Wildlife can only react to changes; in contrast humans have the ability to anticipate changes and help wildlife survive. We must think about actions today that help safeguard our natural and human systems against current impacts as well as prepare for the unforeseen.

Making good, climate-ready choices for our natural resources can also help make our communities more resilient to climate change. Safeguarding our water supply and helping protect our property from storm damage are two examples.

We make these decisions every day. We make decisions to build resilience and restore natural areas and protect our communities. We just need to further prepare to avoid harm from climate-related impacts and costly surprises.



Mark H. Clabaugh

This report, *Improving the Odds: Using Climate-Readiness Planning to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem*, features current climate-ready practices and policies that help build adaptive capacity and pave the way for adaptation in the region. It also identifies tools and future opportunities for action.

A photograph of a sunset over a body of water, likely one of the Great Lakes. The sun is low on the horizon, creating a golden glow that reflects on the water's surface. Several swans are swimming in the foreground, their dark silhouettes contrasting with the shimmering water. In the distance, a long pier or bridge extends across the horizon, and the silhouettes of buildings and trees are visible on the far shore. The sky is filled with soft, wispy clouds, and the overall atmosphere is peaceful yet somber due to the twilight setting.

WE VALUE OUR LAKES.

The Great Lakes are already feeling the effects of a changing planet: warmer water temperatures, less lake ice, and extreme precipitation events. These effects harm the quality and supply of our freshwater.

We must call for aggressive reductions in greenhouse gas emissions, but in the meantime, climate change will place additional strain on our lakes, rivers and wetlands.

The fate of the Great Lakes' aquatic systems and the fish, wildlife and people they support will depend on steps we take to help them survive in the face of a changing climate.

Let's make sure the Great Lakes are ready to handle the impacts of climate change.

THE TIME FOR ACTION IS NOW.

Wisconsin DNR

Part I: Overview of Climate-Readiness

Adaptation and Mitigation

Climate-readiness is another way of describing adaptation to climate change. **Adaptation**, as related to climate change, can be defined as:

Initiatives and measures designed to reduce the vulnerability of natural and human systems against actual or expected climate change effects.⁶

The use of “adaptation” in the climate change context is different than its meaning in the context of evolution, where it refers to changes in an organism’s behavior, physiology or other characteristics to enhance survival to a new environment. For example, a snowshoe hare has large hind feet to keep it from sinking into snow. The hare also changes color seasonally, a dusty brown in the summer and white in the winter to help camouflage itself. These evolutionary changes occurred over time via natural selection.

While some species may be able to adapt to climate change in this classic sense, it is likely that climate change is outpacing the adaptive capacity of many organisms. In addition, many human activities unrelated to climate change have reduced the capability for wildlife to adapt on their own.

Often times the discussion on how to deal with climate change focuses on what is called **mitigation**. Mitigation, as related to climate change, can be defined as:

Technological change and substitution that reduce resource inputs and emissions per unit of output.⁷

What is <i>Mitigation</i> ? Reduces greenhouse gases in the atmosphere.	What is <i>Adaptation</i> ? (<i>Climate-Ready</i>) Reduces harm.
Actions that reduce the amount of emitted greenhouse gases.	Actions that reduce the vulnerability of natural and human systems to anticipated and unanticipated effects of climate change.
Adding carbon sinks to reduce the level of greenhouse gases already in the atmosphere.	Actions that increase the ability or potential to respond successfully to variability and change, through reducing adverse impacts and taking advantage of new opportunities.
Examples of <i>Mitigation</i>	Examples of <i>Adaptation</i> (<i>Climate-Ready</i>)
Replacing a coal-fired power plant with a wind farm.	Development of crop varieties that are more apt to withstand drought.
Planting acres of new trees.	Construction of a wetland for flood control.
Increasing fuel economy or switching to low-emission fuels such as natural gas.	Preventing and controlling the spread of invasive species.
Increasing energy efficiency of an office building.	Extending the border of a state park northward.

Mitigation actions primarily focus on reducing the source of greenhouse gas emissions or removing greenhouse gases from the atmosphere.

It is best to carry out both mitigation and adaptation simultaneously, but it is also important to understand how these actions differ.

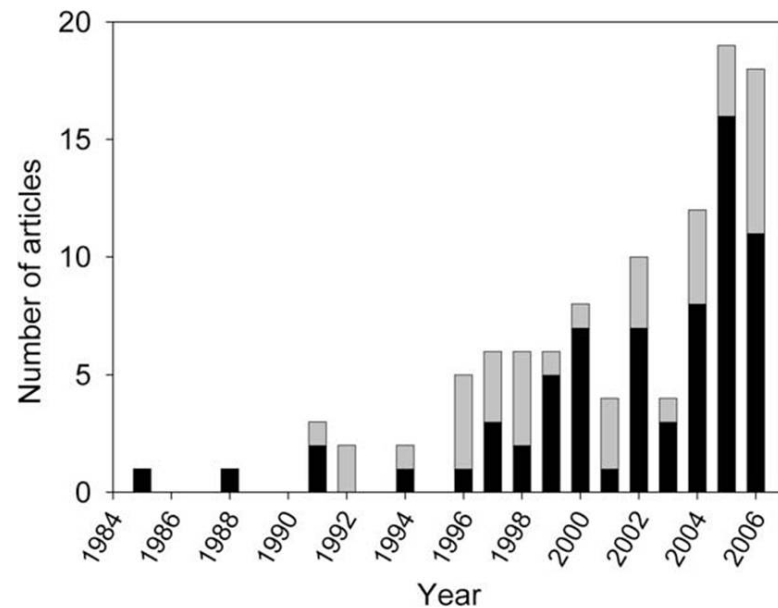
The use of the term adaptation can be confusing. Several alternative terms or phrases are interchangeable or related, including:

- safeguarding against climate change
- acclimatization
- coping with or dealing with climate change
- preparing for a warming world
- managed ecological adaptation
- increasing resilience
- protecting natural resources from climate change
- being climate-smart
- being climate-ready
- surviving climate change

To deem a program “climate-ready” stresses the importance of adaptation activities without giving the impression that they are a replacement for the ongoing fight to curb greenhouse gas emissions. Rather, being “climate-ready” and working to curb emissions through mitigation are simultaneous actions.

Increasing Interest in Climate-Ready Management of Natural Resources

Over the last 20 years interest has grown in climate change adaptation for natural resource management. This figure (below), created by authors Heller and Zavaleta, shows the number of published articles that include biodiversity (showed as black), and biodiversity in conjunction with ecosystem services, suggesting the need for adaptation (showed as gray).⁸



This graph shows an increase in the number of published articles from 1984–2006 which suggest the need for climate change adaptation.

Additionally, U.S. and Canadian policymakers, city officials, and resource managers are recognizing that adaptation will be a part of any strategy to combat climate change and its effects. For example, the latest directive from U.S. Department of Interior Secretary Salazar includes both climate change mitigation and an adaptation strategy for the U.S. Fish and Wildlife Service.⁹

C limate-Readiness and Clean Energy Solutions

Climate-readiness also includes addressing the impacts of clean energy solutions, not just changes in climate. The transition to a clean energy economy must safeguard the very natural resources that keep our communities safe, healthy and prosperous. We must find a balance between the siting of clean energy facilities and the health and sustainability of our natural resources and communities. Given the vast scale of this development, it will be essential to site and configure clean energy infrastructure that minimizes or avoids environmental impacts.

Return on investment is 1.6 : 1

A 2009 report by Fondazione Eni Enrico Mattei (FEEM), a non-profit, non-partisan research institution established to carry out research in the field of sustainable development, says that, worldwide, for every \$10 trillion spent on adaptation, an economic benefit of \$16 trillion will be gained.¹⁰

F ramework

In the report *A New Era for Conservation: Review of Climate Change Adaptation Literature*, the authors compiled a framework to be used by resource managers to guide the adaptation process.¹¹

These are the five principles that form the climate-ready adaptation strategy for resource managers:¹²

1. Select conservation targets and reduce other non-climatic stressors.

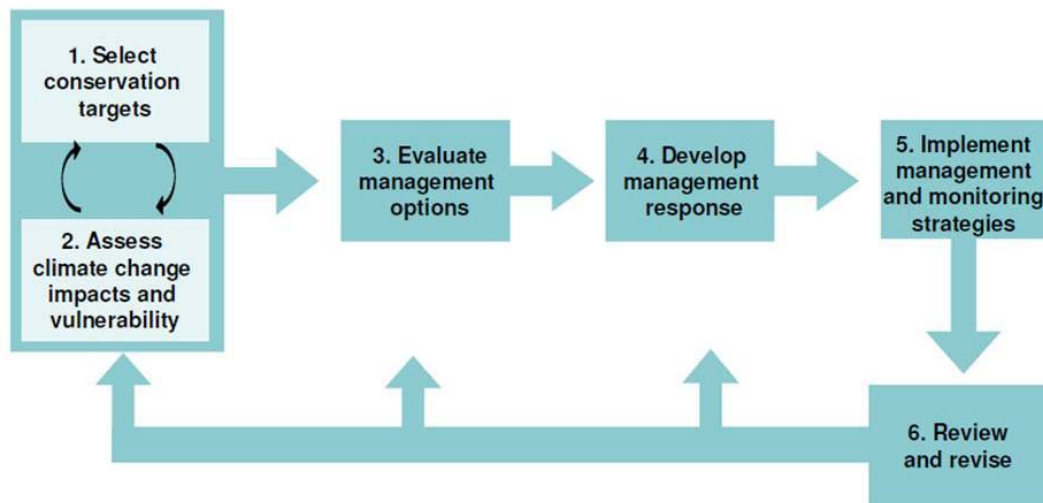
Addressing other conservation challenges—such as habitat destruction and fragmentation, pollution, and invasive species—will be critical for improving the ability of natural systems to withstand or adapt to climate change. Reducing these stressors will increase the resilience and adaptability of the systems, improving the ability of a system to recover from a disturbance and return to a functional state.

2. Manage for ecological function and the protection of biological, genetic diversity.

Healthy, biologically diverse ecosystems will be better able to withstand some of the impacts of climate change. Ecosystem resilience can be enhanced by protecting species biodiversity and enhancing ecosystem function.

3. Maintain connectivity and establish habitat buffer zones.

Improving habitat “connectivity” to facilitate species migration and range shifts in response to changing climate conditions is an important adaptation strategy.



This chart demonstrates the steps of a natural resource conservation strategy which incorporates climate change adaptation.

4. Implement proactive management or restoration strategies. Efforts that actively facilitate the ability of species, habitats and ecosystems to accommodate climate change—for example, renourishing beaches, enhancing marsh accretion, planting climate-resistant species, and translocating species—may be necessary to protect highly valued species or ecosystems when other options are insufficient.

5. Facilitate a strategy to increase the capacity for monitoring. Because there will always be some uncertainty about future climate change impacts and the effectiveness of proposed management strategies, careful monitoring of ecosystem health coupled with management approaches that accommodate uncertainty will be required.

There are two parts to the framework process that are continuous. First, it is an iterative process during which one will regularly revisit, review and revise. Second, that there must be an on-going review of the latest scientific observations so that planning is most congruent with the latest findings.

P articipants

Multiple participants and stakeholders should participate in order to create an effective climate-ready strategy. The Great Lakes region, for example, includes participants such as resource managers, planners and decision-makers, industry leaders, Tribal nations, property owners, hunters and anglers, municipalities and binational organizations.

Collaborative action will help to dissolve the all too common structure of working within “silos.” Plus, working together will help with resource collaboration, minimize duplication of efforts and result in a stronger plan of action.

Resilience

The capacity of a system to absorb disturbance and still retain its basic function and structure.

B arriers & Opportunities

We know that greenhouse gas emissions are increasing and that measurable changes in temperature are taking place. However, we are still working to predict exactly what path climate change will take in specific locations. The magnitude of climate change depends significantly on the path of future greenhouse gas emissions. In addition, scientists are still working to understand how lake levels, precipitation patterns, ecological tipping points, and other systems will be affected by increasing temperatures. Developing effective strategies for climate-readiness will require applying strategies that account for uncertainty.



Emerging Predictions:

As we better understand the planet, scientists and planners are able to make more accurate predictions. As such, we should develop climate change emergency and scenario plans within a framework which allows scientific updates to be applied as they emerge.

- **Emergency planning** - Recognize that every strategy will need to be flexible and revisited frequently. Strategies should include an emergency action plan.
- **Scenario planning** - Look to others dealing with similar situations as your own and model a plan similar or learn from their mistakes.
- **Scientific updates** - Establish a mechanism by which stakeholders are continually updated about the latest in climate change impact forecasting. Comprehensive climate information should be available through a national climate service in the near future.

Limited Resources:

Natural resource management budgets generally do not include funds for climate change planning. The following strategies may help with funding:

- **Dedicated funding** - Find a source of dedicated funding. One possibility is the revenue allocated through a federal or state cap-and-trade system or other greenhouse gas reduction mechanism. Another source could be a revenue tax or utility surcharge.
- **Pool resources** - Collaborate with other stakeholders to pool resource (staff, information, funds, etc). Find those who are already experts in

certain areas and engage them. Partner with universities or non-profits to apply for available grants that integrate science and policy.

- **Emergency fund** - Establish an emergency savings fund or stockpile resources to prepare for unexpected costs.

“Environmental” Labeling:

Labeling climate change as an “environmental” problem may lead to two unintentional assumptions: one, it may cause people to overlook the fact that climate change is a problem encompassing all sectors (industry, health, transportation, urban planning, etc) and two, it may fall victim to the common perception that “environmental” problems are a luxury or optional to solve.

- **Integrate** - Ensure that all stakeholders involved in climate-ready planning share with the public the potential impacts of climate change as they relate to their field.

Co-benefits of minimizing the impact of climate change.

- Reduced energy costs from efficiency and reduction in peak load demand.
- Jobs in planning, weatherizing, energy auditing, restoration, planning, etc.
- Improved air quality, water quality, and health.
- Improved quality of life.

- **Transparency** - All stakeholders should set up a mechanism for regular reporting to the public about climate –ready activities and the subsequent results.

- **Increase awareness** - Increase public awareness about climate change impacts and climate-ready options by means of workshops, websites, webinars, social media and other media.

Engage the public in studies of climate impacts. Ask what they’ve seen and noticed that has changed. Ask what stresses they have noticed (i.e. more power outages, heat waves, flooding, insect issues, etc). Engaging the public in this manner will help to make the connection between climate impacts and everyday life more apparent.



Psychological Barriers:

People often delay or avoid action until a reaction is unavoidable. This response tends to be more chaotic and less certain of outcome than preparing ahead of time. To encourage the kinds of actions needed to safeguard communities from climate change it is important to think ahead and focus on shared benefits, particularly in regards to public health.

- **Benefits** - Emphasize the correlation between the actions of mitigation and adaptation. Utilize the opportunity to update infrastructure, protect public health and restore our natural systems. Green roofs, for example, help reduce the amount of energy required for heating and cooling and thus reduce the amount of CO₂ emissions. They will also provide a precipitation buffer, as well as update the aesthetics of the building.
- **Health** - Communicate to the public that actions which benefit wildlife health also benefit human health and vice versa. Health benefits include, but are not limited to: better air and water quality, better warning and protection systems, more green areas and nature parks, and cooler urban areas.



USEFWS

Part II: Climate-Ready Strategies for Water-Abundant Regions

Anticipating Climate Change

As previously discussed, climate-ready strategies are either anticipatory or reactive. An anticipatory strategy for a water-abundant region, for instance, might involve prohibiting new development in and near high hazard flood areas. A reactive strategy, however, might involve repairing and upgrading property in flood areas to hopefully avoid further damages. Thinking ahead about strategies will help guide how we intermingle natural and human systems.

Questions to consider when developing a climate-ready strategy related to water:

- What does planning for a 50 or 100-year flood mean if the frequency of these events is changing?
- How will cities manage storm runoff when precipitation intensity increases?
- How do we respond to drought or lower lake levels?
- In the face of population growth, drought and changing hydrology, how will the Great Lakes region respond to demands for water from cities like Atlanta, Phoenix or Las Vegas?
- How will our irrigated agriculture fields continue to thrive as water becomes less reliable?
- How does our tourism sector deal with beach closings and unsightly invasive species that thrive on water stress?
- How will important wildlife species be affected by changing climate conditions?

Human-oriented and ecosystem-based climate-readiness should not be viewed as a tradeoff, as healthy natural systems are essential for maintaining a strong economy and safe and livable communities. Making interconnected decisions helps reduce the possibility of making the situation worse than it was prior to the climate-ready activity.

Listed below are some examples of strategies for climate-readiness in water-abundant regions in the areas of human health, coastal areas, agriculture and forestry, water resources, and ecosystems and wildlife. Some of these strategies come directly from the US Environmental Protection Agency, while others come from the sources identified throughout this report.¹³

Shoreline Areas & Industry

- Engage state and local governments in defining responses to lake level decline.
- Improve early warning systems and flood hazard mapping for extreme storms.
- Protect water supplies from contamination.
- Identify the environmental consequences of shore protection.
- Promote shoreline protection techniques that support habitat health.
- Evaluate the vulnerability of port facilities and associated infrastructure due to changes in water level. Assess and retrofit as necessary.
- Reduce the shipping season; shift to land transport when necessary.
- Carry lighter loads when shipping through lower lake levels.



Human Health

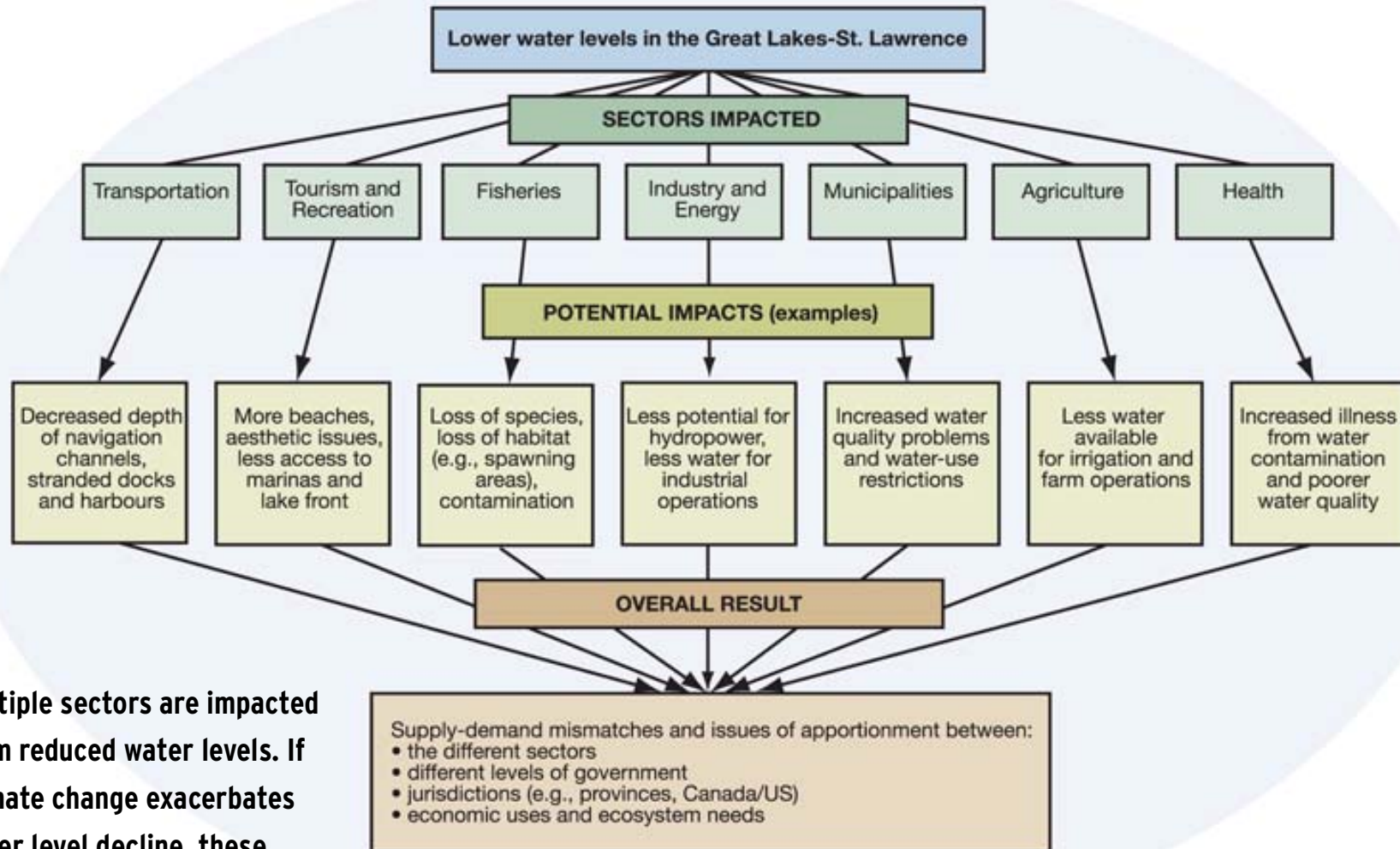
- Plant trees in urban areas to moderate temperature increases.
- Issue weather advisories and alerts to signal the public about dangerous conditions.
- Educate the public about increasing fluid intake on high temperature days.
- Establish heat stress and flood warning systems.
- Limit development in flood-prone areas.

- Implement weatherization programs to reduce heat loads and to shield from cold in winter.
- Ensure roof systems and cladding materials can cope with higher winds.
- Improve natural ventilation in public buildings.
- Reduce ground-level ozone.
- Improve warning systems for days with poor air quality.
- Encourage community gardening and local food procurement.
- Create a state, city, or regional climate-ready emergency fund.

Possible criteria for selecting climate-ready strategies

- Does the strategy protect vulnerable populations, human or wildlife or both, effectively?
- Does the strategy protect against major economic loss?
- Does the strategy reduce stress on natural and human made systems?
- Is the cost for action less than the cost of inaction?
- Does the strategy also reduce greenhouse gas emissions or provide other benefits?
- Could the strategy result in negative effects that are worse than climate impacts?
- Has this strategy worked in the past or for other cities, systems, or regions?

Impacts on Great Lakes Sectors:



Multiple sectors are impacted from reduced water levels. If climate change exacerbates water level decline, these impacts could intensify.

Adapted from Field et al.

Some Great Lakes Basin Cities that already have a city-wide adaptation plan:

Toronto¹⁴

Chicago¹⁵

Quebec City¹⁶

Milwaukee¹⁷

Water Resources

- Improve and update debilitated water-related infrastructure.
- Protect the Great Lakes from increasing outside water demand.
- Install floating docks instead of fixed docks.
- Create natural eco-buffers for vulnerable low-lying areas.
- Improve water use efficiency, planning for alternative water sources (such as treated wastewater), and make changes to water allocation.
- Research ways to reduce evaporation and seepage.
- Relocate intake structures to accommodate lake level changes.
- Conserve soil moisture through mulching and other means.
- Protect freshwater quality from stormwater runoff.
- Update waste water treatment facilities.
- Limit development in flood-prone areas.
- Plant shady trees over streams and ponds to reduce water temperatures.

- Develop response management plans and prevention plans for invasive species.
- Conserve healthy forest, wetland, rivers, and agricultural resources as vital pieces of climate-readiness.

Ecosystems and Wildlife

- Protect and enhance migration corridors to allow species to migrate as the climate changes.
- Identify management practices that will ensure the successful attainment of conservation and management goals.
- Promote management practices that confer resilience to the ecosystem.



- Develop riparian zones.
- Develop response management plans for invasive species.
- Monitor and control pests that arrive due to warmer weather.
- Restore habitat connectivity.
- Encourage public programs for purchase of greenspace and wildlife corridors.
- Develop connected greenway systems for people to access parks, waterways, wetlands, etc.
- Limit fish catches during times when fish are thermally stressed.
- Educate visitors of camping areas on the importance of protecting ecosystem resiliency.
- Enhance conditions for street tree survival and growth (increase space for roots, control soil compaction, increase maintenance, plant appropriate species).
- Incorporate expected changes into land-use decision making.

Agriculture and Forestry

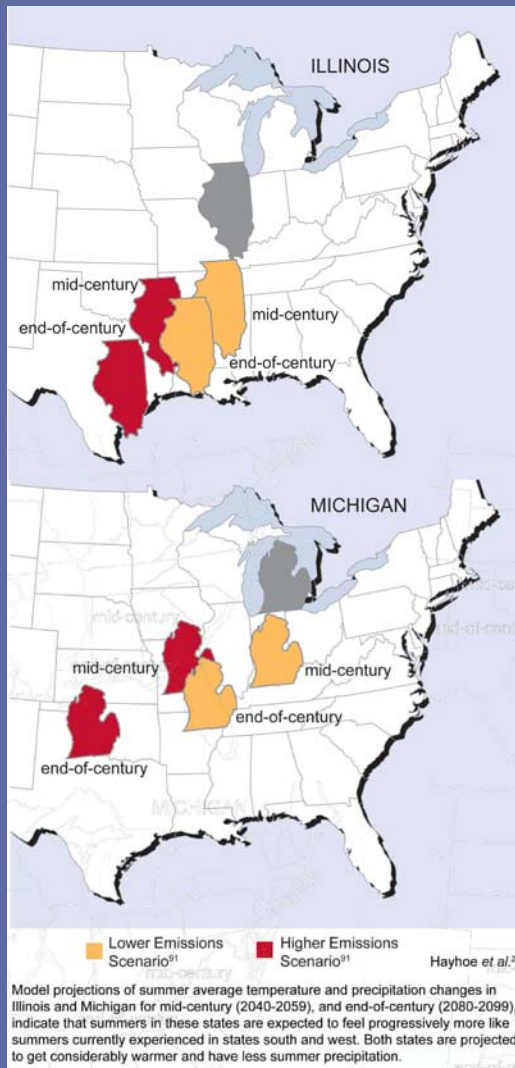
- Support research on climate-resilient crops.
- Alter the timing of planting dates to adapt to changing growing conditions.
- Plant crop mixes and forest species that are better suited to the changing climatic conditions.
- Breed new plant species and crops that are more tolerant to changed climate condition.



- Monitor near-term climate predictions as well as weather predictions.
- Change farming practices to increase soil moisture.
- Encourage water-efficient irrigation.
- Promote fire suppression practices in the event of increased fire risk due to temperature increases.
- Control insect outbreaks and halt the introduction of new invasive species.
- Conserve healthy forest, wetland, rivers, and agricultural resources as vital pieces of climate-readiness.

Projected Climate Change Impacts for the Great Lakes Region

The following provides a quick overview of past records and future scientific predictions of climate change impacts to the Great Lakes.



Air Temperature

Scientists predict an increase of average air temperatures in the summer and in the winter by 2050.¹⁸ As the bordering graphic shows, summers in Michigan could feel more like summers in Indiana mid-century and more like summers in Arkansas by the end of the century. As a result, the growing season may extend a few weeks and hardiness zones will continue extending further northward.¹⁹ Seasonal ice and snow cover may minimize during warm periods.

Evaporation

Mean annual lake surface evaporation has increased as a result of higher lake surface temperatures and decreases in lake ice. This will present particular concern during the summer and autumn months, which already are characterized by low stream flow.

Precipitation

Average daily precipitation is projected to increase in the spring and winter and decrease in the autumn and summer. This means drier soils and droughts during the autumn harvest and more, heavy rain during the spring planting season. All seasons are expected to see a shift toward more heavy downpours or snowfall and less light precipitation.²⁰ Changes in precipitation are not expected to be uniform throughout the seasons or throughout the region.

For more information see www.nwf.org/globalwarming



Water Temperature

The water in lakes and bordering streams could endure warmer temperatures. Data for Lakes Michigan and Huron show a summer surface water temperature of 4.5°F increase over the last 27 years.²¹ Lake Superior's water temperature has increased by more than 5°F since 1985.²² That's about 15 percent faster than the air above the lake and twice as fast as warming over nearby land.

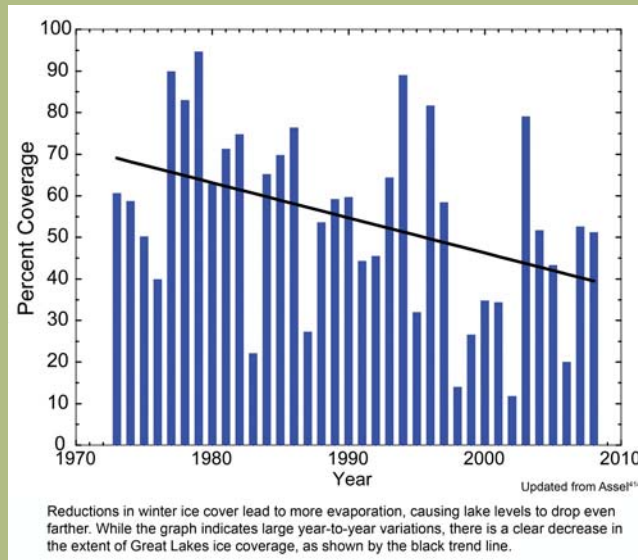


Ice Cover

Noticeable changes occur in the timing of freeze and thaws. As examined by scientists since the year 1840, freezes are occurring later and breakup of ice is occurring earlier.²³ In Grand Traverse Bay on Lake Michigan, for example, the timing of freezes and thaws is catching up to each other. Scientists predict ice cover to be thinner, increasing coastal exposure and evaporation.

Wind Speeds

Wind speeds may increase in certain areas due to increased air and water surface temperatures. For example, in the case of Lake Superior, as warming water influences the temperature differential between the air near the surface and the air higher up, the atmosphere becomes more turbulent. Since 1985, average wind speed has increased by more than 10 percent over Lake Superior.²⁴



Water Levels

Historically, lake levels have dropped most dramatically after years of especially higher air temperatures. For example, lake levels dropped after a 1988 drought and after high air temperatures in 1998. Even though lake levels have gone up in recent seasons, they are still below average past levels. Lake level declines are especially important for Lakes Michigan, Huron, and Superior, where evaporation is a large percentage of water loss in general. Most climate models predict that Great Lakes water levels will drop in the next century.²⁵ These models predict drops during the next century of one foot on Lake Superior, 3 feet on Lakes Michigan and Huron, about 2.5 feet on Lake Erie, and 1.7 feet on Lake Ontario. It is important to consider that lake levels of Superior and Ontario are also affected by the system of locks, hydropower plants, and outflow control mechanisms regulated by the International Joint Commission.

Six Principles of Great Lakes Climate-Readiness

Based on the general frameworks, barriers and opportunities for climate change adaptation, we have identified the following priority principles for the Great Lakes region:

1. Support strategies that protect water levels.

First, a climate-ready approach should ensure strategies that protect water levels in a sustainable and fair manner. We know that the possibility for average lake levels to decline over time is very real. Both human and natural systems stand to lose with lower water levels. Water decline can lead to problems such as exposing shoreline infrastructure, damaging habitats and reducing biodiversity, increased pumping and water treatment costs, changes in shipping channel availability, limiting access to beachfront areas, and increased risk of erosion. We can prevent these problems through sound policy, monitoring practices, conservation efforts, efficient agriculture practices, and by updating debilitated infrastructure.

Adaptive Management

A systematic approach for improving resource management is by learning from management outcomes. This is also known as “learning by doing.”²⁶

2. Reduce other, non-climate stressors.

To reduce overall stress to a system, it is good to reduce other, non-climate related stressors. This is most applicable to stressors stemming from habitat fragmentation, invasive species, and pollution. We must work toward an overall healthy ecosystem that will stand resilient to unpredictable events.

3. Protect biological diversity and ecosystem resiliency.

This principle takes the historical approach to species conservation a step further. We want to ensure that we manage to protect ecological function and biodiversity not in a static framework, but as a dynamic system that changes as the climate changes. How can we best make decisions for the landscape, the food web, and to preserve heterogeneity?

4. Partner to pursue policies that achieve both mitigation and adaptation benefits.

Many climate-ready strategies yield benefits independent of climate change and help to combat climate change. These measures address current vulnerabilities and focus on increasing the ability of ecosystems and communities to cope with current environmental pressures and climate variability. They provide a benefit now, a benefit in the future, and potentially a benefit whether or not the projected climate change impacts cause significant damage. These options are more likely to gain political support given the less uncertain conditions. These approaches will help to save water, energy, and money. For example, green roofs cool the building and the areas around it and retain water (adapts) while reducing energy demand of the building (mitigates).

5. Implement proactive restoration strategies.

Restoration will be increasingly important as species' habitats change and expand. We will need to restore more and more of our degraded lands so that they can survive and thrive in the changing conditions. Efforts that actively facilitate the ability of species, habitats, and ecosystems to accommodate climate change – for example, renourishing beaches, enhancing marsh accretion, planting climate-resistant species, and perhaps even translocating species – may be necessary to protect highly valued species or ecosystems when other options are insufficient.

6. Increase scientific capacity and monitoring.

The science questions will be increasingly more important for planning. Scientists can better inform managers with results of their research. For example, a scientific study could show that if the lake temperature is “x” then reproduction of “y” species will slow. Or that planting “a” species will reduce flooding possibilities for “b” types of floods. We should also develop monitoring protocols to assess ongoing climate-ready work.





ISTOCK

Part III: Examples in Action

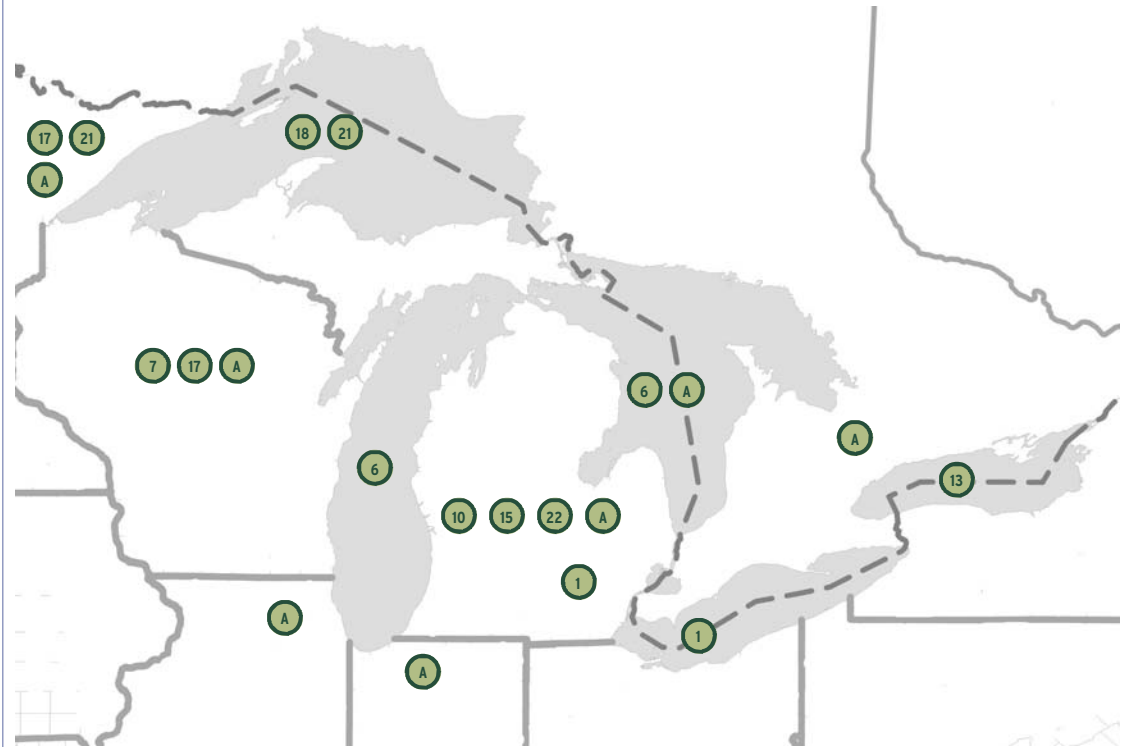
What does climate-readiness look like? Where is climate-readiness happening in the Great Lakes region? Do groups have the resources necessary to implement any climate-ready plan?

This section tackles these questions by highlighting some climate-ready examples in the region. Current climate-ready planning and preparation efforts include developing or amending laws, revisiting existing programs or creating new programs, forming working group and partnerships, and developing scientific guidance through predictive models or assessments. Ensuring that these plans and programs are truly “climate ready” and do not simply represent re-labeled business-as-usual projects requires integrating climate information into planning and on-the-ground activities.

This section highlights various examples of Great Lakes climate-readiness while:

- Introducing projects and assessing project needs for success
- Interviewing key climate-ready leaders
- Presenting tools useful for climate-ready analysis and planning.

Use this map to quickly reference programs in particular states and/or lakes. Those which are basin-wide are listed below. Please also see Appendix A for additional examples.



Basin-wide climate-readiness examples in this section -

2 3 4 5 8 9 11 12 14 16 19 20

More examples in Found Appendix Chart on page 48-

A



ACTIVELY MANAGING FOR PREDICTED CHANGES IN WATER LEVELS:

① Ottawa National Wildlife Refuge

Managers in the Ottawa National Wildlife Refuge are getting ahead of climate change impacts resulting from predicted drops of water levels in Lake Erie. In the southwest Lake Erie marshes (the shallowest part of Lake Erie) the location's habitat is well-suited for migrating birds and marshland wildlife species. As Lake Erie water levels drop the area becomes exposed, the soils dry, and as a result the area becomes habitat more suitable for herbaceous invasive species such as *Phragmites* and purple loosestrife. These species are a threat to native vegetation and the wildlife species which need them for survival.

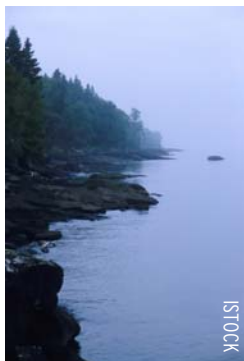
TOOL TO LOOK AT THE SMALLER PICTURE:

② Climate Wizard

The Nature Conservancy and the University of Washington have been working together to develop and maintain Climate Wizard, a user-friendly web-based mapping tool that enables users to identify how climate is projected to change at specific geographic locations. The climate scenario data are based upon general circulation models and emission scenarios. All of the Great Lakes states are included in the tool. One can “zoom in” to examine what temperatures and precipitation amounts they may face based on emission scenarios.

Managers of the Refuge, in partnership with the Ohio Division of Wildlife, are actively addressing the current and future problems caused by water levels. Using controls that even include a beetle species known to consume only purple loosestrife, they are working to eradicate the invasive species and minimize their spread. These efforts are proving successful. The Refuge has seen a reappearance of the endangered eastern prairie fringed orchid, and its population has grown to be one of the largest in the state of Ohio.²⁷

Going forward, local researchers should aid the managers by creating predictions of “new” shoreline as a result of climate change. Tools such as aerial photography and Geographic Information Systems (GIS) overlays should help to communicate this information.



ADAPTATION BUILT INTO LAW:

③ Great Lakes-St. Lawrence River Basin Water Resources Compact & Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement

The Great Lakes-St. Lawrence River Basin Water Resources Compact was signed into law in 2008. The objective of the Compact is to regulate water use and

withdrawal, and to limit diversions from the Great Lakes-St. Lawrence River Basin. Ultimately, the goal is to prevent water withdrawals from causing adverse impacts on the basin's ecosystems and watersheds while protecting the economic and environmental values of the waters for future generations.

The rules, standards, and codes of the Compact are determined and agreed upon by a regional council, and the process is iterative. A potential project that would extract water from the Great Lakes must first pass a review to ensure that the project is in compliance with the Compact.

The Compact is one of the region's most powerful adaptation measures. By providing a rational, legally defensible mechanism to stop Great Lakes water diversions, it protects the Great Lakes from states and nations that will be increasingly thirsty under climate change. It also protects Great Lakes water supplies and the resources that depend on them from unwise water use within the Basin.

In addition, the Compact is a law that is, in itself, adaptable to climate change. It requires that the withdrawal standards be reviewed to, “[g]ive

substantive consideration to climate change or other significant threats to Basin Waters and take into account the current state of scientific knowledge, or uncertainty, and appropriate measures to exercise caution in cases of uncertainty if serious damage may result”.²⁸

In other words, as the climate continues to change over the next decades, the rules, codes, standards and legislations currently in force will be adapted to changing basin conditions. Research will provide the sound scientific basis upon which to base future policy amendments.

RESEARCH NEED:

④ Climate Change Scenarios

Scientists are continually improving the climate change models and techniques. Some ways that scientists are working to aid the climate-ready process are to:

- Downscale climate models to get a more accurate regional perspective.
- Include the Great Lakes as water in the model landcover inputs and outputs. Earlier models assumed the Great Lakes were land and not water.
- Improve forecasts, especially in the case of extreme weather.
- Improve scientific knowledge of climate variability and how it interacts with ecosystem function and the needs of wildlife.
- Utilize mapping tools such as GIS to 'overlay' climate threats.
- Research the impacts of daily low temperature increases and warming at night.
- Improve understanding of climate variability and its effect on freshwater quantity and quality.

The Compact also requires that the standards be reassessed using adaptive management principles and approaches to take into account climate change and other “Basin-wide processes.” Adaptive management includes a systematic approach to evaluation and monitoring, and also emphasizes the inclusion of evolving scientific knowledge.

The Compact is beginning to be tested for its effectiveness, as the first withdrawal requests are underway. So far the request process is running smoothly. Going forward, we need to ensure that predicted lower water levels resulting from climate change are considered in every withdrawal decision.

BRIDGING CLIMATE ADAPTATION SCIENCE & POLICY FOR REGIONAL STAKEHOLDERS:

5 Great Lakes Regional Integrated Sciences and Assessment

The Regional Integrated Sciences and Assessment (RISA) program is funded by the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office. RISAs support the scientists who address complex climate-related issues that are of particular concern to regional resource managers and policy planners. Locations of RISAs include the southwest, the Pacific Northwest, California, and the southeast. Until this year, there was no RISA team in the Great Lakes region.

This year, NOAA granted resources for the development of a Great Lakes RISA. The goals of the Great Lakes RISA are to contribute to the long-term sustainability of the Great Lakes region in the face of multiple and simultaneous changes, including regional climate change, and to improve the utility of scientific knowledge in decision making.

More specific goals are to:

1. Develop an integrated network of stakeholders who will contribute to the co-production of policy and usable science,
2. Conduct high-quality scientific research to address substantial gaps in current knowledge,
3. Compile, synthesize, and compare existing climate knowledge in the region and, through interaction with stakeholders, develop new approaches to enhance their usability; and
4. Develop best practices for the use of climate projections in impact analysis and decision making.²⁹

The Great Lakes RISA is innovative in that it is designed around a flexible research program that includes the input and deliberation from both scientists and regional stakeholders. An archive of climate projections and best practices for the Great Lakes region will aid in their planning and evaluation processes.

‘APPLICABLE’ SCIENCE OF FISH POPULATIONS IN THE GREAT LAKES:

6 USGS Great Lakes Science Center and the National Wildlife Federation

For managers and conservationists of Great Lakes fisheries, the effects of climate change on fish population are largely unknown. Scientists at the United States Geological Survey (USGS) Great Lakes Science Center are presenting an opportunity for state management agencies to examine climate change effects on fish populations by downscaling global climate

Climate-Ready Champion

Don Scavia, Director of the Graham Sustainability Institute, Ann Arbor, MI



Don Scavia is the Graham Family Professor of Sustainability, Professor of Natural Resources and Environment, Professor of Civil and Environmental Engineering, Director of the Graham Sustainability Institute, and Special Counsel to the U-M

President for Sustainability.

He holds Bachelors, Masters, and Doctorate degrees in Environmental Engineering from Rensselaer Polytechnic Institute and the University of Michigan, has published over 70 articles, and led development of dozens of interagency scientific assessments and program development plans.

Why is climate-readiness important for the Great Lakes?

While reducing greenhouse gas emissions is critically important, the climate is and will continue to change for the foreseeable future with or without those mitigation efforts. While

mitigation will help frame what the future will look like, we have to prepare our cities, resource managers, and citizens to adapt to the new climate. Without appropriate adaptation, the Great Lakes region will not be able to recover from the current economic slump, nor will it be able to restore and protect its critical natural resource base.

What are the tools we have in place for adaptation?

Some critical tools are reliable forecasts of what the regional climate will look like. Statistical and mechanistic downscaling climate products are getting better, but an important focus is needed to get them to be more robust and reliable. While advances in regional climate forecasts are needed, many of the required resource management and development tools are already in our tool kit. In most cases, climate change puts added stress on already stressed systems and the tools we already employ to reduce those stresses or increase resiliency to those stresses are available.

How do we distinguish normal restoration activities under the Great Lakes Restoration

Initiative, for example, from climate-ready restoration?

In many ways, they are the same, but climate change alters how one thinks about restoration. For example restoring or protecting shoreline habitats for conditions where water levels fluctuate around a long-term average could be quite different when one considers lake levels might drop significantly over the next decade or so. For example, what might be a nicely restored wetland (or protected urban area) might be high and dry in the future. One needs to ask “how can we restore or protect areas now in ways that make sense under a new climate regime.

What is the most promising commitment to climate-readiness you've seen recently?

I think many of the state provisions associated with the Great Lakes Compact are “climate ready” or can be made so with relatively simple modifications. Probably the most promising adaptation activity I have seen so far is a willingness among stakeholders from government, business, NGOs, and academia to begin discussions on what will be needed to adapt to the coming changes.

models to regional scales and linking these models with ecological and biological responses of fish populations.

USGS scientists will work closely with state management agencies and the National Wildlife Federation to complete several objectives that will provide knowledge to aid their planning and management strategies in anticipation of coming changes. Researchers will first update a regional Great Lakes climate model to predict water level changes, water temperatures, and ice cover data for the entire Great Lakes basin 50-100 years into the future. Researchers will also use satellite data to determine whether the recent climate warming has influenced the timing and magnitude of algal production in lakes Michigan and Huron. They will then use long-term data sets and time series models to explore how climate influences variability in fish production in lakes Michigan and Huron.

These models will be used along with future climate predictions to forecast future fish production over the next 50-100 years in these lakes. Researchers will explore how warmer water temperatures will influence the growth and consumption rates of several managed Great Lakes fish species.³⁰ The National Wildlife Federation will collect and present conclusions of this study that will be useful for decision makers and resource managers throughout the Great Lakes region.

ADDRESSING IMPACTS IN URBANIZED AREAS AND DEVELOPING A ROADMAP FOR WILDLIFE:

7 Wisconsin Initiative on Climate Change Impacts

The Wisconsin Initiative on Climate Change Impacts is a joint project of the Wisconsin Department of Natural Resources and the University of

TOOL TO IMPROVE WILDLIFE MANAGEMENT:

8 Vulnerability Assessment

Plant and animal species vary widely in how they are likely to respond to changes in temperature, precipitation, and other factors brought about by climate change. Vulnerability refers to the likelihood that these climate-induced shifts will have an adverse impact on a given species, habitat, or ecosystem. More vulnerable species and systems are likely to experience greater impacts from climate change, while less vulnerable species and systems will be less affected, or may even benefit.

Vulnerability assessments are a key tool for adaptation planning, and an essential first step as states begin the task of updating their wildlife action plans to take climate change into account. By detailing the ecological impacts and implications of climate change on our wildlife, vulnerability assessments can help managers:

- Identify those species and systems most likely to be in need of conservation actions as a result of climate change;
- Develop adaptation strategies tailored for managing species and habitats in greatest need;
- Foster collaboration at statewide and regional scales by providing a shared understanding of impacts and management options; and
- Allow scarce resources for wildlife conservation to be allocated efficiently in the face of climate change.

TOOL TO IDENTIFY VULNERABLE GREAT LAKES SPECIES:

⑨ NatureServe Climate Change Vulnerability Index

The NatureServe Climate Change Vulnerability Index can help identify Great Lakes plant and animal species that are particularly vulnerable to the effects of climate change. Created as a user-friendly Excel file, one could apply readily available information about a species' natural history, distribution and landscape circumstances to predict whether it will likely suffer a range contraction, population reductions, or both during the coming years.

Some applications for the Index are:

1. As part of a variety of analyses, including assessing the relative risk of species listed in State Wildlife Action Plans.
2. As part of any assessment of the vulnerability of species to climate change.²⁸

Wisconsin. This group works to combine climate modeling and research with local planning. Local leaders are provided with up-to-date climate modeling capabilities and field expertise that will allow them to assess impacts at a level relevant to their region.

WICCI scientists are expecting that some species, such as the American marten or spruce grouse, may no longer find suitable habitat in the state, while other species, such as white tailed deer, turkey, and opossums may increase their numbers.³¹

The WICCI formed a wildlife working group to address these and other issues. The group works to evaluate vulnerabilities, not just to the ecosystem or highly climate sensitive species, but also to the economy and within the political structure. Their conclusions are ongoing, but some of their early findings are that laws protecting endangered and threatened species may need to acknowledge that some species will become extirpated from Wisconsin due to climate change and adjustments may need to be made for bag limits and harvest seasons due to changes in migration patterns.

The wildlife group is working collaboratively with other WICCI groups such as forestry and agriculture to synthesize existing climate research as it pertains to Wisconsin's wildlife resources. In addition to examining risks, they are outlining a 'roadmap' for adaptive management that is frequently updated and includes the input of stakeholders throughout the state.

WICCI is also fostering local efforts. A special Working Group formed for the city of Milwaukee in February of 2008 to address the gap in understanding of impacts and to formulate adaptation strategies for the built environment and surrounding natural systems. Participants include local city managers, water managers, and representatives of the private and public health sectors. One example of their work is a collaborative project with the Milwaukee Sewerage Department. This project will deliver estimations of the change in the number of sewage overflows based on rainfall patterns. This information guides plans to implement adaptive measures, such as combined sewer overflows, based on different climate and weather scenarios.³²

WICCI is a model for climate-ready planning and action for other states. Going forward, WICCI should consider hosting a forum, say, a "WICCI on

the road,” in each of the Great Lakes states to present the how, why, who, and results of the Initiative. Another possible result of the “WICCI on the road” could be recruitment of other stakeholders for the development of a Great Lakes region-wide WICCI-type collaborative.

STEPS TO HELP GREAT LAKES WILDLIFE SURVIVE A CHANGING CLIMATE:

10 National Parks Conservation Association

The National Parks Conservation Association released a climate-ready planning guide in 2009 called *Wildlife: A Survival Guide for a Warming World*. The guide includes steps that the National Park Service (as well as other natural resource officials) can take to safeguard wildlife from the effects of climate change. One section of the guide proposes solutions for Great Lakes ecosystems.

The general climate-ready steps for all parks include:

1. Stop contributing to climate change.

INCREASING AWARENESS:

11 Climate-Ready Planning & Sharing Experiences

Dialogue and interactions between those hoping to and those who are already undergoing climate-ready planning is essential. A mechanism could be applied such as an online network or a workshop that facilitates these discussions and would allow for sharing of data, analysis, forecasts from experts so that decision makers will have the information to advance climate-ready solutions.

2. Reduce and eliminate existing harms that make wildlife more vulnerable to climate change. For the Great Lakes, this includes reducing water pollution and invasive species that stress waterfowl, shorebirds, and migratory birds that visit Sleeping Bear Dunes National Park.³³
3. Give wildlife freedom to roam. This involves interconnecting public and private land so that species have a better opportunity to adapt on their own.
4. Adopt “climate smart” management practices. This involves integrating climate change into everyday work and providing the funding and staffing needed to deal with the challenge.
5. National parks lead by example. National parks serve as natural education centers as well as natural laboratories to test innovative ways to build climate-ready ecosystems.



Some of the National Parks that reside in the Great Lakes region are Pictured Rocks National Lakeshore, Cuyahoga Valley National Park, Sleeping Bear Dunes National Lakeshore, Apostle Islands National Lakeshore, and Isle Royale National Park. The guide suggests some climate-ready solutions to help these areas withstand the impacts of climate change. One measure is to further control phosphorous runoff that feeds algae growth. Climate change may foster algae growth by causing more runoff from large storms and by creating conditions—warmer water—that foster

more growth. Another solution is to prevent invasive species from entering the lakes, thus preventing more challenges to the stressed ecosystem. Another solution on which National Parks are well-versed is public education. They have a great opportunity to educate the public on climate-ready planning and safeguards for wildlife.

Going forward, the NPCA should update this survival guide as the climate changes and more is known about how to safeguard wildlife. They should also do a cost-benefit analysis to examine the benefits and costs of expanding park size to allow for adaptation-related movement of species and protection of ecosystem services.

STAYING AHEAD OF THE EVENT:

12 FEMA Pre-Disaster Mitigation Grant Program

The Pre-Disaster Mitigation (PDM) program provides funds to states, territories, Tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects *before* a disaster event. Receiving funds ahead of time, rather than after an event, is a good climate-ready strategy. For example, Miami-Dade County of Florida utilized these funds to strengthen buildings against hurricanes, including university buildings and homeless shelters. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on disaster funds. PDM grants are awarded on a competitive basis and without reference to state allocations, quotas, or other formula-based allocation of funds.

BINATIONAL STRATEGY TO PROTECT LAKE ONTARIO:

13 A Biodiversity Conservation Strategy

This strategy was prepared by the Nature Conservancy and Nature Conservancy Canada for the U.S.-Canada Lake Ontario Lake Management Plan (LaMP). It's goal is to describe key threats to the area and some strategies to deal with these threats. In the strategy climate change is listed as one of the top five threats. As such, the sixth recommendation of the strategy is to plan and adapt for climate change.³⁴

The two recommendations related to adaptation include:

1. Through watershed planning and management, provide corridors and linkages to facilitate the movement of species and shifts in ecological communities.
2. Modify the regulation of Lake Ontario and watershed management regulations to accommodate the impacts of climate change. Levels in lakes, rivers, and groundwater are likely to change as the climate changes, and management of lake and river levels through dams and other mechanisms needs to be flexible enough to change accordingly.

The authors of the strategy also recommend a scientific study, on-the-ground activities, and a binational working group. The scientific study would involve a detailed bathymetry of nearshore waters linked seamlessly to coastal topography to permit mapping of critical nearshore habitats and modeling of the potential impact of lower lake levels. The on-the-ground activities would be to manage streams as natural systems, while integrating

NATIONAL ADAPTATION INITIATIVES TO REDUCE VULNERABILITY:

14 Center for Disease Control and Prevention

The Centers for Disease Control and Prevention (CDC) has a Climate Change Program that engages in a number of climate-ready activities in order to address human vulnerability to changes in their environment.³⁶ For example, the CDC helped develop a web-based modeling tool to assist local and regional governments to prepare for heat waves. For cities like Detroit a toolkit can assist in proper steps to alert populations of the health risks due to hotter weather.

climate change into water withdrawal decision making. The strategy calls for a binational adaptive management working group to recommend measures to enhance restoration of natural flows in the St. Lawrence River.

Going forward, a dedicated stream of U.S. federal and Canadian funding is needed to finance these recommendations. Near-term actions of the strategy should include GIS and watershed tool analysis, establishing an adaptive management group, and for New York and Ontario to revise stormwater regulations. LaMP members are calling for new regulations of “new” shorelines that may emerge if water levels decline, including restrictions on moving existing shoreline protection structures.

INTEGRATING CLIMATE CHANGE FOR WILDLIFE PLANNING:

15 Michigan State Wildlife Action Plans

In order to receive funds through the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program, Congress charged each state and territory with developing a wildlife action plan. These proactive plans, known technically as “comprehensive wildlife conservation strategies,” assess the health of each state’s wildlife and habitats, identify the problems they face, and outline the actions that are needed to conserve them over the long term.³⁵

This past year, the Michigan Department of Natural Resources, National Wildlife Federation, and Michigan United Conservation Clubs convened a workshop on how to integrate climate change into the Michigan State Wildlife Action Plan. Workgroups assessed problems like the management response to adaptation, shaping federal or state policy, and implementation of the current Wildlife Action Plan. Some important research needs that would help the Action Plan move forward were identified, including:

- coarse filter biodiversity conservation assessments,
- vulnerability assessments,
- connectivity planning,
- identification of invasive species vs. natives,
- information and education,
- translocation,
- response of microbes, and other species tied to ecological processes in a less obvious way to climate change.

ON THE LOOK-OUT:

16 National Weather Service & National Climate Service

The National Weather Service is a service provided to residents of the United States that includes weather forecasts, storm warnings, radar maps and other visuals that help individuals plan, and inform in case of emergency.

NOAA is set to release a National Climate Service sometime in the near future. Like the Weather Service, the Climate Service will be a single, regulated, comprehensive source for climate information and predictions. This long-term climate information will be continually updated and will result from partnerships with NASA, the U.S. Fish and Wildlife Service, the Department of Agriculture, the Centers for Disease Control and Prevention, the Environmental Protection Agency, the Department of Energy, and the Department of Transportation. With this information communities and regions can understand, mitigate and adapt over time to climate variability and change.

Participants concluded that they will need a host of climate-ready plans to tie in with Wildlife Action Plans. These are reminiscent of the popular “choose your own adventure” books where participants choose and explore different scenarios. Multiple plans and scenarios will help to deal with the uncertainty of climate change.

Going forward, we need to ensure that the Michigan Wildlife Action Plan and others around the region receive funding and support. The state budget is unlikely able to fund these important research needs, so the state must

find other avenues of funding, including federal funding. Some of the research needs should be delegated to state academic and other research institutions.

PLANNING FOR TINY CARRIERS OF DISEASE:

17 Minnesota and Wisconsin Health Departments

Ticks carrying the powassan virus cause encephalitis—inflammation of the brain. Tick-borne encephalitis is listed by environmental health scientists as likely to change in the quantity of human disease cases, or in the geographic range of vectors or reservoirs as a result of climate change.³⁷ Recently, Minnesota and Wisconsin Health Departments have noticed the virus expansion into their states. 2009 brought Minnesota’s first death from Rocky Mountain spotted fever and second-ever case of brain inflammation from powassan virus. The tick spreading the powassan virus was not found north of southern Iowa until recently, but its populations are growing and expanding. Other species that change behavior may also contribute to the tick spread. If birds or mammals move into new territory, for example, to find cooler temperatures, the ticks may come along with them.

Plans to study tick movement and develop actions to prepare are underway in Minnesota, Wisconsin, and Canada. These plans may include, for example, public and outdoor enthusiast education and notifications for doctors to be vigilant of symptoms of these new diseases.

Going forward, these and other Great Lakes states will need to be vigilant of emerging diseases in order to protect the public. States should undergo assessments of human vulnerability by utilizing toolkits such as the web-based modeling tool of the Center for Disease Control and Prevention (CDC).

Climate-Ready Champion

Rebecca Humphries, Director of the Michigan Department of Natural Resources and Environment



Rebecca Humphries has been Director of the Michigan Department of Natural Resources since 2004, and has recently been appointed by Governor Granholm as Director of the new

Department of Natural Resources and Environment. Humphries is responsible for the administration and direction of the department, which has thousands of employees and a multi-million dollar budget that supports programs for wildlife and fisheries management, state parks and recreation areas, conservation and law enforcement, forest management, permitting, state lands and minerals, and communications.

Humphries is a graduate of Michigan State University, with a degree in fisheries and wildlife, and has completed course work toward her MBA through the University of Wisconsin. She was awarded an honorary Ph.D. in public service from Central Michigan University in December 2004.

Why is climate change adaptation important for Michigan wildlife?

Climate determines the distribution and abundance of wildlife in Michigan. Climate change appears to be accelerating to the point that it should be considered over scales of years to decades, rather than centuries to millennia. We also know that effects of climate change will likely vary across ecosystem types. We must, therefore, prioritize our resources and time to manage those terrestrial and aquatic systems that are most vulnerable to the effects of climate change, such as species near the southern edge of their range and ecosystems that have high social and economic values. Management planning that effectively utilizes our resources and time will assist in identifying ecosystems that are resilient given climate change, and help us avoid investing in areas or activities that would prove futile.

One example regarding climate change is for game species whose life history attributes are dependent on snowfall. For example, if snowfall continues to increase as predicted, then there could be implications for

management of species like deer, marten, and lynx whose distributions are tied closely to snow-depth and duration. Ergo, adaptation of planning efforts would be focused on managing those geographic areas for habitat attributes in anticipation of the changes in wildlife distribution.

What are the tools we have in place for adaptation? What tools do we need?

The foundation for climate change adaptation is our present and historical investment in science to help us understand fish and wildlife populations for their better management. We can build on this research with our long history of monitoring and assessment surveys and historical datasets that are geospatially referenced. These datasets allow us to analyze land and waterscape trends that will be necessary for future management planning. We also have in place significant investments in population models that can be used to assist in predicting effects on populations, given changes in warming trends and accumulations in degree-days.

We need:

- Downscaled climate predictions.
- Predictions of lake level change.
- Vulnerability assessments.
- A geographic analysis of resilience.
- No regrets strategies.

Stakeholders that need to be involved include the organized hunting, fishing, and conservation organizations, professional organizations, as well as individuals.

What could happen to Michigan wildlife if adaptation does not take place?

Climatic and weather changes will likely change how ecosystems function, including how species interact with each other and the ecosystem. Likely effects on species include:

- Increases in invasive species, pests, and diseases.
- Increases in rates of extinction.
- Uncoupling of predator-prey relationships.
- Migration or dispersal events might not coincide with availability of food (berries, insects).
- Uncoupling of parasite-host relationships.

Without adaptation, we may miss the opportunity to protect certain high priority aquatic resources that can be maintained under climate change. We may also lose important ecological services like groundwater recharge that could be costly to our communities.

What is the single most alarming impact of climate change on Michigan?

Actually, we believe there are two potential effects of equal importance. First, Michigan is unique in that it has two biomes separated by a tension zone. I would very much miss the components of our northern areas, such as walking through jack pine or spruce, moss or lichen underfoot, and the chance of seeing a pine marten, moose, or hearing a loon in the distance.

Second, the loss of winter ice on inland lakes and on the Great Lakes may result in tremendous amounts of evaporation, dropping lake levels, changing shoreline configurations, and possibly net losses in coastal wetland areas. We have done far better than maritime states in protecting our coastal ecosystems and it

alarms me that those past conservation successes may be at risk.

What is the most promising adaptation activity you've seen recently?

Particularly promising are the Landscape Conservation Cooperatives and their partnership with regional Climate Centers under the auspices of the US Geological Survey. These partnerships could pull on the expertise of multiple states, federal agencies, and universities to coordinate and answer critical research questions. If structured wisely, they would also close the loop between managers and researchers such that research questions are meaningful and managers actually receive useful research outputs. Finally, they would stimulate regional thinking, which will be useful as new wildlife species and the issues they bring begin to move into new areas.

CLIMATE-FRIENDLY & CLIMATE-READY PARK:

18 Apostle Islands National Lakeshore

The Apostle Islands National Lakeshore is made up of 21 islands off of the coast of Bayfield, Wisconsin in Lake Superior. Designated as a Climate-Friendly National Park, steps are already underway to reduce the park's greenhouse gas emissions. Park Superintendent Bob Krumenaker has also recognized the need to make the park climate-ready, as the park is already experiencing localized impacts from climate change.

Superintendent Krumenaker is adamant that climate change is not simply an environmental issue and that these changes need to be addressed:

- Safety issues from thinning ice on the Madeline Island Ice Road over Lake Superior require a public emergency plan and warning system as well as retooling facilities and access points.³⁸
- Public health issues including heat extremes, spread of West Nile Virus and respiratory issues require public education and warning systems.
- Changing island coastlines with more extreme fluctuations in lake levels require monitoring and adjustment of access points or boating restrictions as necessary.
- Drying wetlands, reducing biological diversity, fisheries, and wild rice beds require a more aggressive invasive species management.
- Intense storms over the lake that present dangers to boaters require a clear warning system, adjustments to access points as necessary, and possible fines for those who do not comply.

Going forward, the Superintendent Krumenaker or others at the Lakeshore should report on their successes and not-so-successes. Perhaps the Indiana

ONLINE CLIMATE ADAPTATION DATABASE:

19 Climate Adaptation Knowledge Exchange (CAKE)

Climate Adaptation Knowledge Exchange (CAKE) is a climate adaptation knowledge sharing database aimed at building a shared knowledge base for managing natural systems in the face of climate change. Having started in 2010 by both Island Press, a publisher of environmental information, and EcoAdapt, a non-profit dedicated to ecological adaptation; the goal of the exchange is to host a community of climate change adaptation experts and knowledge. CAKE developers will also vet and clearly organize rapidly-changing climate change adaptation information.

The database consists of four interlinked components:

- Virtual library - links to climate change adaptation articles and information in books, action plans, literature, journals, reports and case studies as managed by an on-site editor.
- National Case Studies - links to on-the-ground adaptation projects throughout the country while sharing results, approaches, challenges and ideas.
- Directory - links to people who are working on climate change adaptation projects in a region or area of interest and their contact information.
- Adaptation Tools - links to current climate change adaptation tools that help guide a user through climate change information and make decisions.

Dunes National Lakeshore (see chart in next section) should be a partner in these climate-ready efforts. That way, the Lakeshores share knowledge and best practices. The Apostle Islands serve as a model for other National Lakeshores.

CLIMATE-READY RESTORATION PRACTICES::

20 Freshwater Future and National Wildlife Federation

Identifying and implementing restoration solutions that are climate-ready will help us gain the best return on investment for our restoration practices. With \$475 million through the Great Lakes Restoration Initiative (GLRI) set aside for restoration projects in 2010, we cannot afford to ignore the effects of climate change while implementing these practices. Freshwater Future, a non-profit who provides assistance to citizens and grassroots watershed restoration groups throughout the Great Lakes basin, and National Wildlife Federation's (NWF) Great Lakes Regional Center are partnering to work with those doing on-the-ground restoration. Part of this work will include efforts to inform and develop ways to make their practices climate-ready. These efforts will include collaborative workshops and the communication of 'actionable' science.

Some examples of climate-ready restoration practices that Freshwater Future and NWF will advise groups to put into practice include:

- Planting shady vegetation to reduce water temperatures.
- Temporarily adding water to extend species' natural adaptation time.
- Creating berms or hills for organisms to take shelter during high velocity stream flows.
- Broadening species diversity to increase system resiliency to change.

- Identifying species or ecosystems most at risk from climate impacts.

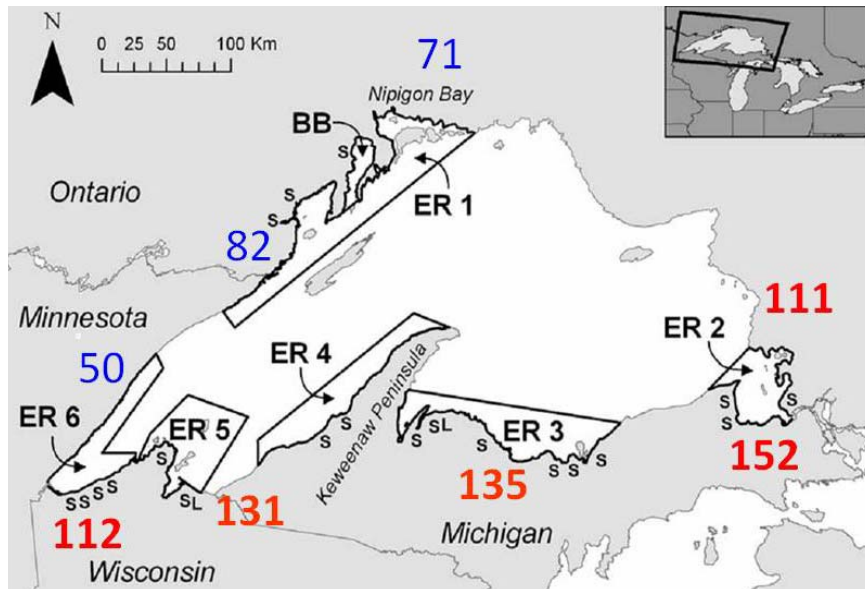
Going forward, the National Oceanic and Atmospheric Administration (NOAA) is working with NWF to develop ways to implement climate-smart restoration. There will be two avenues: first, NWF will help advise on GLRI applications to make applicant projects climate-smart, and second, NWF will help groups receiving funding implement and evaluate these strategies. Meanwhile, NWF will help to promote the NOAA National Climate Service as a means for climate information.

CONTROLLING SEA LAMPREY POPULATIONS IN A WARMING LAKE SUPERIOR:

21 University of Minnesota and the Minnesota Department of Natural Resources

Sea lamprey are parasitic jawless fish that prey on the tissue of a wide variety of fish. Victim fish like lake trout, whitefish and herring typically die from excessive blood loss. Lamprey introductions into Lake Superior started in the early 1900s. Though the invasive sea lamprey are not yet eradicated from Lake Superior, lamprey control methods such as electric current, chemical lampricides, and barriers have been successful. Since the beginning of control methods in the 1960s to today, lamprey populations have gone from over a million to about 200,000. The Great Lakes Fishery Commission (GLFC), a joint commission of the United States and Canada, lead efforts of this control.

Changing climate conditions create more challenges for control efforts, however. Since 1975, scientists led by Dr. James Kitchell at the University of Wisconsin have noticed that lampreys in Lake Superior are getting longer



This map shows the number of days Lake Superior water temperatures were above 10°C (50°F) in 2009 By EPA Eco-region (ER). Areas of particular urgency for sea lamprey management are shown in red.

and weighing more. They notice that weight increases are in the range of 35 – 40% during the last 40 years. At the same time, temperatures of water in Lake Superior are rising. Kitchell’s analysis suggests that open-water Lake Superior summer temperatures have increased by roughly 3.5°C (36°F) over the last century, with most of that warming occurring in the last three decades.³⁹ Correspondingly, the length of the positively stratified season has increased from 145 days to 170 days. Plus, reduced winter ice cover over Superior on average has decreased from 23% to 12% over the last century. Sea lamprey fare better in warmer water, especially in days with water

greater than 10°C (50°F). As water temperatures warm they are able to live longer and grow larger. The results are dire for fish populations. Simply put, bigger lampreys kill more fish.

Control managers are adapting their efforts to climate change. They integrate climate change and water temperature information into these efforts. Scientists give control managers water temperature and occurrence information (i.e. days with temperatures 10°C or higher) by ecoregion. Lamprey control efforts receive a boost in cases of warmer temperatures over longer periods of time. The graphic is an example of a map control experts use for information. In this graphic, Lake Superior is divided by the six ecoregions (as indicated by “ER”). Days with water temperatures of 10° C or higher are indicated in the red and blue fonts. The numbers in red are areas of special importance for lamprey control.

Going forward, we need to ensure that the Great Lakes Fishery Commission gets the funding they need to continue efforts and/or to step up efforts in a changing climate. Other efforts that would also help control efforts include research recommendations related to changes to food web interactions and to fish populations as Superior warms. If native fish populations get stressed by warmer water, for example, lampreys could be better able to decimate them. Another recommendation is that the GLFC and other control experts should also work to control lampreys in adjacent streams. Stream temperature should be monitored in order to gauge priority streams for control efforts. We should also work to prevent new invasive species from entering Lake Superior.

REDUCING EMISSIONS AND ADAPTING TO CLIMATE CHANGE THROUGH SUSTAINABLE INITIATIVE:

22 City of Grand Rapids, Michigan

The City of Grand Rapids is weaving climate change mitigation and adaptation into multiple city initiatives. Grand Rapids is one of the first cities in the Great Lakes region to be a member of Local Governments for Sustainability (ICLEI). ICLEI is an international association of local governments as well as national and regional local government organizations who have made a commitment to sustainable development.⁴⁰ The association's goal is to build a network of local governments that learn from each other but also hold each other accountable to take action on climate protection.

In 2009 the Mayor created an Office of Energy and Sustainability. This action dedicates City staff to planning for and working towards climate mitigation and adaptation for all sectors of the economy.

Protecting energy infrastructure in a changing climate is a goal of the City of Grand Rapids. This goal is realized in two ways. One, by reducing demand on such infrastructure via energy conservation, and two, by committing to the reduction of greenhouse gas emissions through implementation of renewable energy. The City is working toward a reduction of annual electricity use by 107,000 MWh by June 30, 2013 and plans to achieve 30% of such energy from renewable resources.⁴¹

Spring and summer air temperatures and heat wave potential are expected to increase for Grand Rapids as a result of climate change. In order to adapt to these changes, the City plans to increase the percentage of tree canopy

from 35% in 2008 to 37.5% by 2015. Tree canopy helps to reduce urban air temperatures to protect public health as well as ecosystem health.

Going forward, the City of Grand Rapids should continue to move from the planning stage to the action stage. Since the City has led other cities on so many initiatives, those others will be looking to Grand Rapids for results and best management practices. Grand Rapids could also work to expand their Community Sustainability Partnerships (CSPs), the multi-stakeholder group dedicated to promoting sustainability, or work to establish CSPs in neighboring cities. As the Grand River is such important lifeblood to the City, the City should monitor changes to the river that result from climate change. That way, the City will have the knowledge to deal with changes that could potentially cause harm to the river.

See Appendix A on page 48 for more examples of climate-ready actions in the Great Lakes region.



Part 4: How Federal Policy Will Aid These Activities



A NEW CLIMATE-READY ENERGY ECONOMY:

Federal Energy Legislation

Federal clean energy legislation being discussed in the Senate has very important provisions for adaptation. The legislation sets out a framework for

helping people and wildlife cope with the impacts of climate change, focusing on efforts abroad and on domestic efforts.

The domestic portion of the legislation has two main components:

- Protecting and restoring U.S. species, habitats and ecosystems threatened by climate change.
- Protecting societal assets such as public health and public infrastructure.

Any funds generated for the purpose of component number one will flow directly to federal and state natural resource agencies. For the Great Lakes region, a state-based program would be established to assist coastal states, which include the Great Lakes states. This legislation specifies that certain assets such as infrastructure, energy facilities, or resources of national significance may be protected or relocated under the program. Approved uses of program funds would include strategies that use natural buffer zones, natural shorelines, and habitat protection and restoration.

PROTECTING WATER QUALITY FROM CLIMATE CHANGE:

Great Lakes Water Quality Agreement

In 2009, U.S. Secretary of State Clinton and Canadian Foreign Minister Cannon announced that they will renegotiate the Great Lakes Water Quality Agreement, a significant bi-national agreement that helps protect water quality in the Great Lakes region. Clinton said, "The agreement was last amended in 1987, and since then, new invasive species have appeared in our lakes, new worrisome chemicals have emerged from our industrial processes, our knowledge of the ecology of the region and how to protect it has grown considerably. In its current form, the Great Lakes agreement does not sufficiently address the needs of our shared ecosystem. We have to update it to reflect new knowledge, new technologies and, unfortunately, new threats." Amongst the new threats Clinton discussed is climate change.

Environmental groups such as the National Wildlife Federation, Great Lakes United, and the Alliance for Great Lakes are working diligently to make sure that the updated agreement will address growing issues and consequently be more 'climate-compliant.' These groups are active in public/government consultations. The consultations will be on nine issue areas: toxic substances, nutrients, nearshore, aquatic invasive species, biodiversity, groundwater, ship source pollution, science coordination and climate change. This is the first time climate change has been considered for the Agreement.

RESTORATION FOR GREAT LAKES FUTURE:

U.S. Environmental Protection Agency (EPA) Great Lakes Restoration Initiative (GLRI)

President Obama proposed and Congress enacted \$475 million for a new Great Lakes Restoration Initiative (GLRI) in the FY 2010 Budget. Headed by the U.S. EPA, eleven agency and cabinet organizations are working together to develop and implement a restoration plan. That plan draws heavily on the 2005 Great Lakes Regional Collaboration Strategy (GLRC) developed by federal, state, tribal, industry, non-governmental partners and other stakeholders. This budget and plan distributes the first years funds as follows:

- \$60 million to prevent or control aquatic invasive species.
- \$146 million to clean up toxic hot spots.
- \$105 for habitat and wildlife protection and restoration.
- \$97 million to improve near-shore health and address nonpoint source pollution.
- \$65 million to evaluate and monitor progress.

These activities are Great Lakes climate-ready activities because they increase the resilience of our natural systems. However, it is also important to consider how climate change and future conditions can be incorporated into restoration projects so that these natural areas are healthy for the long-term. The President has proposed \$300 million for Great Lakes restoration in the FY11 budget and has promised to allocate a total of \$5 billion for restoring the lakes.

Conclusions and Lessons Learned

There is much to learn from the journey through the Apostle Islands National Park, the city of Milwaukee, the wildlife of Michigan, the biodiversity of Lake Ontario, and other places benefiting from the work to safeguard our human and natural systems from the impacts of climate change.

The good news is that stakeholders throughout the region are beginning to get the plans in place and collaborations necessary to incorporate climate change into their various activities. These activities will not only protect our natural systems from the impacts of climate change, but also our infrastructure, our public health, and our freshwater way of life.

However there are still some challenges:

- **Implementing the Plans** First, many of these climate-ready measures are plans. The plans need to be implemented – they need to result in on-the-ground climate-ready actions. We have a lingering concern that these comprehensive climate-ready plans will meet their fate on an office shelf. One way to make sure planning becomes action is to integrate climate change adaptation into currently on-going resource management activities. For example, if an agency is taking action to restore fish spawning habitat, examine the climate predictions for future water temperatures so that the project can be designed accordingly (e.g. adding shady vegetation to reduce water temperature). Another technique is to consider the next steps and the viability of moving a plan forward before and as it is being drafted. Consider, are the resources, collaboration and dedication in place to facilitate a fulfillment of the plan? If not, address what steps are necessary to assist you towards this goal.



- **Funding and Staffing** Second, governments lack funding and staffing for any type of resource protection work, especially climate adaptation work. Managers, planners, and organizations are already at the edge of what their budgets allow. Often dealing with climate change is considered as additional and is not calculated into a yearly budget. One way to grow resources is to find a source of dedicated funding. One possible source is the revenue allocated through a federal or state cap-and-trade system or other greenhouse gas reduction mechanism or through a revenue tax. Another way to overcome a lack of funding is to pool resources together. Stakeholders could pool their resources (staff, information, funds, etc), to find those who are already experts in certain areas and engage them. Agencies can partner with universities or non-profits to apply for available grants that integrate science and policy.

- **Making Climate Change a Priority** Third, we need to get away from the thinking that climate change is somehow an “extra” or an “added layer” to already complex issues. Climate change affects all issues and sectors and is woven into everything we do. Costs of inaction will likely be higher than the costs of action. We need to remind decision makers that they already have years of experience dealing with floods, droughts, erosion, and other natural disasters; considering changes in climate will make their work better. We should also increase awareness about climate change impacts and climate-ready options by means of workshops, websites, webinars, social media, and other media. Agencies should engage the public in studies of climate impacts; they should ask what changes the public has seen, what stresses they’ve noticed (i.e. more power outages, heat waves, flooding, insect issues, etc). Engaging the public in this matter will help to make the connection between climate impacts and everyday life.

We can and must meet these challenges, and fortunately, help is on the way. Legislation, education, leadership and knowledge sharing will aid effective Great Lakes climate-readiness.

The Great Lakes Restoration Initiative, described in the previous section, is a grand opportunity to invest in restoration and protect our systems from climate change. This year, the first year of the Initiative, about \$475 million is available to clean, restore, and sustain the health of the Great Lakes region. Restoration is in itself an adaptation strategy, as it helps keep our systems, natural and human, resilient in uncertain conditions. We must uphold the pledge of President Obama to continue this funding. It makes ecosystem health sense and economic health sense. According to the

Brookings Institution for every dollar we spend on restoration of the Great Lakes, between two and four dollars of economic activity occurs.

Federal clean energy legislation currently being discussed in the Senate has very important provisions for adaptation and the Great Lakes. The legislation sets forth a two-part framework for helping people and wildlife cope with the impacts of global warming, focusing on efforts abroad and efforts at home. Any funds generated for the purpose of domestic efforts will flow directly to federal and state natural resource agencies.

Another key is education. We must educate the public on the impacts of climate change and why we have to be ready to cope with those impacts. And we must make the solutions clear and achievable. This area can quickly become complex and technical; we need to provide solutions that people understand and want to implement. For example, establishing a National Climate Service through NOAA will help make climate change information as accessible and ubiquitous as the weather.

Leadership is increasingly important to protect the Great Lakes from climate change. Talented, informed, dedicated leadership can ensure that plans become action. Leaders should surround themselves with experts in various sectors to gain the information and collaborations necessary for planning and implementing effective adaptation measures. And we need to encourage and support the leaders who are trying to take action.

Finally, sharing knowledge among practitioners as they develop new management strategies and between the conservation and climate change science communities is essential if we are to meet the challenge of managing natural resources in the face of climate change. With so much new



information available about how the climate is changing and options for conservation responses, networking and tools will be needed to facilitate information exchange among experts working in discrete locations.

The waters of the Great Lakes region are wonders of the world. Home to one-fifth the surface freshwater in the world, the Great Lakes provide drinking water to more than 30 million people. The Great Lakes region boasts the headwaters of the Mississippi River, plays an integral role as both a migratory route and home for waterfowl, and supports one of the most productive freshwater fisheries in the world. The vast water resources support communities large and small and are the foundation of industrial companies, mom-and-pop businesses and farms. Yes, the Great Lakes and their waters are places where families go swimming, catch fish, and watch sunsets; but they are more. They are the economic drivers for the region. They compose our identity; they define who we are.

But today the vast waters and coastlines of the Great Lakes are under siege from a changing climate. The lakes are already experiencing the effects of climate change, and those effects will only get worse. Certainly we must slow and stop global warming pollution as soon as possible, but even if we do so and avoid the most severe changes in climate, we will still see some changes, and they will be significant. So the lakes and the people and wildlife who depend on them must be smart. We must adapt. We must put into place today the policies and projects that will protect us ten, twenty, fifty years down the road.

We can and we will do this together. Planning for climate change is much easier and less expensive than suffering from the disasters we will see if we take no action. With an educated public and informed leaders, the Great Lakes and the people and wildlife who depend on them will be ready for climate change.

Appendix A

Agency/State/City	Action Plan	Status	Assessed Needs
City of Chicago Project Scope: Water, urban infrastructure, human health, nearshore habitat, vegetation. Funding Source: City and private funds. Amount unknown. Timeline: 2008–Present.	- City completes a Climate Action Plan with both a Mitigation AND Adaptation plan. - City determines five key areas of adaptation: extreme heat, extreme precipitation events, infrastructure vulnerabilities, ecosystem degradation, and leadership, planning and communication. - City raises funds to complete a risk assessment and cost analysis. - Risk assessment involves downscaled climate information and impact data. - Risk assessment tells city official how likely a climate-related risk such as flooding or extreme heat is to occur and its associated costs to the community. - City identifies urban “hot spots” using advanced satellite imagery and GIS software to reduce health risks of citizens. - City creates a gardening plan that includes species more resilient to anticipated climate conditions.	Finishing planning stage, moving into actions. Current Activity: - Implementation of urban green roofs, tree planting, development of warning systems, new reflective roof standards, green infrastructure. Scale of these activities is currently unknown. - Incorporating projected climate conditions into stormwater planning at the watershed scale.	- Public education on ways to plan for climate-related risk. - Funding to implement additional green roofs and urban gardens. - Implementation of actions in plan at city-wide scale. - Ongoing monitoring and studies that include emerging climate predictions.
International Joint Commission Project Scope: Water and nearshore wetland habitat. Funding Source: Public funds, about \$17 million for entire study. Timeline: 2007–2011.	- In 2007 the International Joint Commission commissions the International Upper Great Lakes Study (IUGLS). - Results from IUGLS could influence how the lake levels are regulated. - Phase I of the IUGLS is to examine whether possible physical changes in the St. Clair River and other factors are contributing to the lower average levels of Lakes Michigan-Huron, compared to Lake Erie (i.e., head decline). - Phase II of the Study is to examine whether regulation of outflows from Lake Superior might be improved to take into consideration changing climate, ecosystem protection, and evolving interests of property owners, local governments, the shipping sector, and the recreational boating and tourism industry.⁴²	Phase I complete. Phase II ongoing through 2010. Current Activity: - No direct remediation or restoration action taken yet. - May lead to possible remediation of the St. Clair River and/or changes in regulation of Lake Superior.	- Examine feasibility of ecological restoration of St. Clair River to stem water losses. - Examine condition of the St. Clair River pre-dredging (pre 1960's) in order to compare to post-1960's results of IUGLS. - Consider climate change impacts on the Lakes in Phase II of the IUGLS.⁴³

Agency/State/City	Action Plan	Status	Assessed Needs
State of Michigan Climate Action Council Project Scope: Natural resources, wildlife, coastal habitat, fisheries, urban infrastructure, human health. Funding Sources: State funds. Amount unknown. Timeline: 2007-2009	• Governor Jennifer Granholm issues Executive Order No. 2007-42 establishing the Michigan Climate Action Council (MCAC) in 2007. • The MCAC is made up of a broad base of industry, utilities, state and local government, academia, and environmental interest groups. In March of 2009 the MCAC issues a comprehensive climate change plan for Michigan. • The plan includes an assessment of climate change impacts to Michigan, including likelihood of occurrence of the impacts, and recommendations for adaptive measures.⁴⁴ • Council support of developing an adaptation plan was unanimous.⁴⁵ The MCAC recommends that Michigan conduct additional analyses of the state's vulnerability to the impacts of climate change and develop specific adaptation plans for key sectors. • Communications, research, and funding were called for to assess and plan for climate change's impact on Michigan's land and natural resource-based industries.	Funding restrictions hinder progress of MCAC. Current Activity: • Envisions sector-by-sector state and county adaptation activities. • Still in recommendations phase, not quite a plan. • Future actions resulting from plan uncertain.	• State and/or federal dedicated funding source. • A multi-stakeholder team that will work to integrate climate adaptation into existing and future natural resource management plans and, where possible, related research and assessments. This may include, for example, the State Forest Management Plan; Wildlife Action Plan; Coastal and Estuarine Land Conservation Plan; Aquatic Nuisance Species State Management Plan; fisheries management plans; watershed management plans; infrastructure assessments; and species-specific management plans. • A state office dedicated to natural resource adaptation. • Implement actions recommended by private and public sector. • Monitoring, evaluation, and reporting of implementation.
Forest Managers in Michigan, Wisconsin, Minnesota Project Scope: Forests, habitat, wildlife, water, human health. Funding Sources: Federal funds. Timeline: 2008-Present.	• Actions of forest managers across these states are based on a report by the U.S. Forest Service states that land management must be capable of enhancing adaptation of these ecosystems to increasing climate changes while removing carbon from the atmosphere through sequestration in ecosystems and wood/energy products.⁴⁶ • In response to possible climatic changes or effects from fires, forest managers are researching the management of a more diverse forest mix. Diversity could reduce long-term risks and impacts from a changing climate.	Research and planning stage incorporating fire management practices. Current Activity: • On-going fire management under unstable climate conditions. • On-going management of invasive species. • Re-vegetation of forest with a diverse mix of species.	• Multi-national plan and actions that also involve Tribal nations and Canada. • Dedicated emergency funds. • Further research and monitoring to incorporate emerging climate predictions. • Implement current recommendations of U.S. Forest Service. • Monitoring, evaluation, and reporting of implementation.

Agency/State/City	Action Plan	Status	Assessed Needs
City of Toronto Project Scope: Human health, urban infrastructure, water. Funding Source: City of Toronto, Environment Canada. Timeline: 2007-2009.	• City investigates the probability and severity of an extreme storm event and associated health and economic impacts. • With the probability information, the city creates a citywide risk matrix to inform city planners. • Collaborative partners include planners, real estate experts, resource managers, and insurance experts.	City-wide risk matrix complete, city officials consider information in decision making. Current Activity: • Dedicated city staff that work on adaptation. • Citywide warning systems. Public health education and information. • 29 recommendations guide actions on vulnerability, partnership building, communication, and health and infrastructure protection.	• A sector-by-sector plan of action. • A city development plan that inhibits growth or development in high-risk areas. • Monitoring, evaluation, and reporting of matrix applications.
The Nature Conservancy and Michigan State University Project Scope: Water, watershed habitat, human health. Funding Sources: Private funds, university research funds. Timeline: 2008-Present.	• Michigan State University's Institute of Water Research and The Nature Conservancy are partnering in order to inform projects in Michigan's Paw Paw watershed in southwestern Michigan. • The plan has two parts: first, to determine where to focus climate-ready and conservation efforts, and second, to determine how much land must be conserved to successfully preserve the natural system. • They are looking more in-depth at how to abate the effects of extreme precipitation on sensitive aquatic systems.	The project is in the research phase. Current Activity: • Climate-ready decisions and solutions could be identified for the Paw Paw watershed by having scientists examine and communicate information on flow alteration and options for coping with "flashiness."	• After research and planning, resource managers will need to use it on the ground. • Evaluate project upon completion. If successful, model could be applied to other areas in the region. • Monitor the Paw Paw watershed to minimize response time.

Agency/State/City	Action Plan	Status	Assessed Needs
Michigan Department of Natural Resources and Environment Project Scope: Wildlife, forests, habitat. Funding Sources: State funds, some federal. Timeline: 2009-Present.	- Protects Kirtland's warblers in a changing climate. The Kirtland's warbler is an endangered bird and one of the rarest members of the wood warbler family. - Kirtland's warblers rely on Jack pine forests, which may respond rapidly to projected global warming. - If the climate warms as predicted, in about 50 years quaking aspen and oaks will replace the pines along the southern margin of their range.⁴⁷ The causes of this 'replacement' include; invasive species like the pine beetle destroying jack pine population and abrupt changes in temperatures crippling pine growth. - The Michigan Department of Natural Resources and Environment is taking a number of steps including analyses and inter-agency collaboration to examine Kirtland's warbler vulnerability to climate change and how to address this vulnerability.	Research of ways to reduce Kirtland's warbler vulnerability to climate change underway. Current Activity: Possible steps for climate-ready warbler protection to be outlined in a Michigan Department of Natural Resources and Environment report due out summer 2010.	- Research of ways to reduce jack pine vulnerability to climate change. - Integrate emerging climate predictions into ongoing research. - Further funding sources for Kirtland's warbler protection. - Monitoring of Kirtland's warbler behavior. - Evaluation and reporting of implementation results.
Minnesota Department of Natural Resources Project Scope: Wildlife, forests, human health, habitat. Funding Source: State funds, some federal. Timeline: 2008-Present.	- Minnesota's Department of Natural Resources (MDNR) adds to its department-wide objectives,⁴⁸ "Adaptive management and expansion of conservation areas help maintain plant and animal populations by allowing species to migrate or adapt in response to climate change". - The Minnesota DNR recognizes that Minnesota's climate will continue to change over the next 50 to 100 years. - The agency will take climate-ready management actions such as creating wildlife corridors, improving habitat connectivity, and expanding habitat buffers to facilitate plant and animal migration as climate changes. - Managers will apply their conservation "toolbox" in new ways to address the effects of climate change as it compounds other stressors such as habitat fragmentation and invasive species.	In process of transitioning from recommendations toward action. Current Activity: - Conserving six million acres of peatlands, which are important working carbon stocks. - Building multi-national conservation networks to protect moose from the effects climate change. - Leading a collaborative climate and watershed research project called Sustaining Lakes in a Changing Environment, or SLICE.	- Evaluation of conservation "toolbox" effectiveness. - Communication/collaboration with other states in the region. - Continuous monitoring of species and integration of emerging climate predictions. - Reporting of results regionally.

Agency/State/City	Action Plan	Status	Assessed Needs
Center for Clean Air Policy Project Scope: Water, human health, urban infrastructure, wildlife. Funding Source: Private funds, some federal. Timeline: 2009-Present.	• Creates the Urban Leaders Adaptation Initiative. • Great Lakes cities include Milwaukee, Chicago, and Toronto. • Cultivates partnerships and identifies climate-ready opportunities and policies such as FEMA's Hazard Mitigation Grants and the Water Utility Climate Alliance.	Completed a report identifying adaptation policies and practices. Ongoing partnership development and education of city officials. Current Activity: • Informing city officials of climate-related risk during land-use decisions making. • Implementing green infrastructure. • Grant application assistance to help cities secure federal climate-ready grants.	• Expansion of efforts to more Great Lakes urban areas. • Expansion of efforts to smaller metropolitan areas. • Information to city officials on where to get comprehensive climate information. • Monitoring of climate-related risk to urban infrastructure. • Evaluation of successes and opportunities for improvement.
Province of Ontario, Grand River Conservation Authority Project Scope: Water, human health, habitat, agriculture, wetlands. Funding Source: Provincial funds, Environment Canada. Timeline: 2006-Present.	• With a drainage area of 6,800 km² (2600 mi²) the Grand River Watershed is the largest watershed in southern Ontario, bordering Lake Erie at the south. Agriculture is the main economic driver of the watershed. • The Grand is managed by the Grand River Conservation Authority (GRCA) to control floods or to supply in cases of drought.⁴⁹ Due to their management responsibilities, the Authority has a strong economic and safety impetus to plan for climate change. • Some impacts from climate change on the Grand include increased flooding and erosion, reduced water quality, and reduced fisheries, wetland and marsh habitat. Three goals of the GRCA for climate-readiness include: (1) Evaluate the GRCA flood control and flow augmentation infrastructure and determine if current operating policies and procedures will serve the watershed needs into the future. (2) Review design standards to ensure stormwater is delivered from the landscape to a safe outlet. (3) Review existing emergency response plans to prepare for extreme flood events.	Reviews of existing emergency response plans are underway. Current Activity: • Practices such as implementing riparian buffers, planting trees, enhancing and restoring wetlands, restricting livestock access to watercourses, and putting more water storage back on the landscape through the GRCA's Rural Water Quality Program.⁵⁰	• Encourage agricultural water conservation strategies. • Evaluate the need to move or expand buffer zones. • Continuous monitoring and ongoing integration of emerging climate predictions. • Implement design standard for stormwater management. • Provide resources to implement the recommendations to GRCA. • Evaluate successes and opportunities for improvement.

Agency/State/City	Action Plan	Status	Assessed Needs
City of Detroit Project Scope: Water, urban infrastructure, human health. Funding Sources: Private funds. Timeline: 2009.	• Green alleys are updated concrete alleyways with permeable pavements and open-bottom catch basins to funnel more rainwater back into the ground. • A green alley exists near Canfield and Prentis Streets in midtown. • Capable of protecting residents from large storms that may result from climate change; the alley is also made of renewable and recycled materials such as tire rubber. • Water is kept within the natural water table of the Great Lakes basin.	Currently one green alleyway exists. Funding constraints prohibit expansion of program. Current Activity: • Existing alley holds up to a 10-year storm without water going into the storm drain.	• Inform city officials of benefits of green alleys in Detroit. • Fund additional green alleys. • Require all new construction or infrastructure updates to implement green alleys. • Evaluation of successes and opportunities for improvement.
Menomonee Valley Sustainable Redevelopment Project Scope: Wildlife, human health, water, habitat, urban infrastructure. Funding Sources: Private funds, some state, city and federal funds. Timeline: 2007-Present.	• Due to climate change Menomonee Valley, WI experienced two 100-year flooding events over the past decade. • The Menomonee Valley spans four miles long by half a mile wide, extending from Lake Michigan into Milwaukee, Wisconsin. Originally a marsh, since the 19th Century the area has been filled, developed, dumped upon, and the Menomonee River straightened. The area was home to tanneries, stockyards, and lumberyards that caused much detriment to the natural environment. As these industries abandoned the area they left behind a blighted and contaminated landscape. • Throughout the Valley, industrial waste has been replaced by 25 acres of native wetland grasses and plants. Also, property owners in the Valley are required to plant 80% native species and swales to catch stormwater. • Restoration activities help protect against extreme flooding events that carry contaminated run-off to more widespread natural areas.	Phases such as clean-up and recreation development complete. Additional work to manage stormwater on-going. Current Activity: • Since the landscape has been restored, there has been an increase in wildlife numbers. For example, the blue heron is now visiting the Valley again. • Ecosystem services provided by the 140 acres of floodplain are being restored. • Hills and berms previously leveled by development are being restored.	• Collaboration with the Wisconsin Initiative on Climate Change Impacts (WICCI). • Continuous monitoring of species such as the blue heron. • Evaluation of successes and opportunities for improvement. • Integration of emerging climate predictions into design.

Agency/State/City	Action Plan	Status	Assessed Needs
City of Ann Arbor, MI Project Scope: Urban infrastructure, human health, wildlife, habitat. Funding Source: City funds. Timeline: 2007-Present.	• In 2007 the city implements a new rate structure for the stormwater utility fee. • To reduce the amount of stormwater input, the City of Ann Arbor decides to incentivize residents that reduce stormwater runoff. • The utility rate is determined by the amount of impervious area on a property (as determined by a computer analysis of aerial infrared photography). As an incentive, residents have the opportunity to earn credits to reduce their bill by reducing the amount of water flowing off of their property.⁵¹	Rate structure implemented. Monitoring sewer input by neighborhood to determine success. Current Activity: • Residents reduce amount of water flowing off of their property and in response, get a reduced rate in city utility fees.	• Ensure that the utility rates adequately cover the emerging needs of the city under changing conditions. • More public education programs on how residents can reduce the amount of water flowing off of their properties. • Evaluation of successes and opportunities for improvement.
Various stakeholders in Milwaukee, Wisconsin Project Addresses: Wildlife, habitat, botany Funding sources: Unknown Timeline 2008 - 2010	• In August of 2008 a group of managers, scientists, economists, attorneys and conservationists met in Milwaukee, Wisconsin to examine the viability of assisted migration, the action of manually relocating species in order to help them survive a changing climate, for local species. • The group did not reach consensus on assisted migration for any species, in part due to concerns about competition with un-assisted species and difficulties in determining conservation priorities. • Scientists and managers revisited their earlier conclusions in 2009. Jessica Hellman, a biologist at the University of Notre Dame, and a member of the working group, said, "The community was not in the right place to be talking about this issue until recently."	Stakeholders continue to assess assisted migration, no plans to assist migration of species in Wisconsin yet. Current activity: • The Chicago Botanic Garden is seeking permits to test the concept of assisted migration with the threatened Pitcher's thistle by pushing it into new, colder territory along the shores of Lake Ontario.	• Examine the viability of assisted migration in more detail. • Run a vulnerability assessment, perhaps on the Pitcher's thistle. • Review of other assisted migration actions and whether or not they are successful • Develop guiding principles on what constitutes an invasive species and under what circumstances the species could be deemed non-invasive because of the changing climate conditions.

Agency/State/City	Action Plan	Status	Assessed Needs
Minnesota Department of Natural Resources, Native American natural resource agencies, local tourism and the United States Forest Service Project Addresses: Wildlife, habitat Funding Source: Unknown Timeline: 2009 - Present	• Moose habitat spreads over Minnesota, Ontario, Wisconsin and Michigan in the Lake Superior region. • Climate change and parasite transmission contribute to moose population decline in the region. In the Agassiz National Wildlife Refuge, for example, the moose population has declined or shifted northward dramatically. Populations in the refuge have gone from 250-400 to about 40. • To plan for moose management in a changing climate, stakeholders from the Minnesota Department of Natural Resources, Native American natural resource agencies, local tourism and the United States Forest Service are drafting recommendations.	Release of the stakeholder recommendations late 2010. Current Activity: • On-the-ground climate-ready management of moose begins after recommendations are finalized.	• Run a vulnerability assessment of moose. • Ensure that funding and resources are available to carry out the stakeholder recommendations. • Utilize this example as a way to call-out to our policy-makers to safeguard these important mega-fauna.
Natural Resources Defense Council and Rocky Mountain Climate Organization Project Addresses: Habitat, wildlife, water, human health Funding Source: Unknown Timeline: 2009 - Present	• Natural Resources Defense Council and Rocky Mountain Climate Organization recommend ways for “national parks in peril” to deal with climate change impacts. • Climate change affects the Indiana Dunes National Lakeshore in these ways: loss of ice and snow, more downpours and floods, loss of wildlife, loss of winter recreation, loss of plant communities and tourist overcrowding due to more pleasant temperatures. • Some of their recommendations to decrease the vulnerability of Indiana Dunes to climate change include: expanding the park size to allow for movement of species and reduce non-climate threats such as invasive species. • Other recommendations of the organizations include developing a park-specific climate-ready plan while considering various climate scenarios for park management and making climate change a National Lakeshore priority.	Recommendations become public in 2010. Current Activity: • Lakeshore management is beginning to examine options to implement recommendations.	• Coordinate ecosystem and climate change research for the Lakeshore. • Ensure that funding and resources are available to carry out the recommendations. • Monitor our national parks, as they are the primer indicators of change. • National lakeshore management should convene and share best practices for dealing with climate change.

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