

Climate Change Adaptation Plan for Coastal and Inland Wetlands in the State of Michigan



**A White Paper Prepared for the
Michigan Department of Environmental Quality
Wetlands Program
and
Coastal Management Program**



**Association of State Wetland Managers
September, 2012**



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ACKNOWLEDGEMENTS

Financial assistance for this project was provided, in part, by the Michigan Coastal Management Program, Michigan Department of Environmental Quality, through a grant from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. We wish to thank Anne Hokanson of the DEQ Wetlands Program, and Alisa Gonzales-Pennington of the DEQ Coastal Management Program for their suggestions and assistance in preparing the white paper. We also wish to acknowledge the DEQ Wetlands Program and the Michigan Wetlands Association for their efforts in convening the Wetlands Climate Change Symposium that provided the foundations for this work.



Climate Change Adaptation Plan for Coastal and Inland Wetlands, State of Michigan - Draft Report

Introduction: Michigan's Commitment to Addressing Climate Change

Climate change is occurring in the Great Lakes region. Between 1968 and 2002 average temperatures increased 2.3 degrees Fahrenheit. The average annual ice coverage on the Great Lakes declined 72% between 1973 and 2010. The average number of snow days has decreased more than 15 days since 1975. These trends are expected to continue along with changes in the frequency of intense storms, extended droughts and heat waves.

http://www.glista.msu.edu/docs/fact_sheets/GLISA_climate_change_summary.pdf



These changes are likely to have a profound impact on the citizens of the State of Michigan, as well as the state's natural resources including wildlife, fisheries, wetlands, lakes, streams, rivers, forests and grasslands. In 2007 Governor Jennifer Granholm signed Executive Order 2007-42 creating the Michigan Climate Action Council (MCAC) charged with developing a comprehensive climate change action plan focused primarily on Greenhouse Gas reduction goals, but also addressing actions to adapt to climate change. The Council published a comprehensive report in March 2009. http://www.michigan.gov/documents/deq/deq-miclimateactionplan-part1_276563_7.pdf The plan supports conservation of natural resources as one of the many goals of the plan.

In November of 2010 the Michigan Climate Coalition was formed through Michigan State University in collaboration with "Michiganders" interested in climate science, energy efficiency, sustainability and related disciplines. <http://miclimatecoalition.org/index.html> The Michigan Climate Coalition includes several working groups, some of which are focused on coastal/Great Lakes issues, Inland Waters and Wildlife/Terrestrial Systems.

In March of 2011 Michigan Coastal Management Program, Office of the Great Lakes, Department of Water Quality published the "Section 309 Assessment and Five-Year Strategy for Coastal Zone Management Program Enhancement Fiscal Years 2012-2016" http://www.michigan.gov/documents/deq/deq-ogl-mcemp-Section309Strategy2012-2016_369789_7.pdf which included a chapter on "Climate Change Adaptation in Coastal Wetland Management."

Finally, a number of organizations collaborated in the fall of 2011 to host a Symposium on Wetland Management in Response to Climate Change. Held in conjunction with the Michigan Wetlands Association Annual Conference (August 30 – September 2, 2011 at the Grand Traverse Resort in Acme, MI) – the conference brought together over 150 scientists, policy makers, and agency staff from state, federal, local, and nonprofit organizations in a broad review of wetland and climate change issues. Highlights included a conference keynote address on wetland adaptations and climate change in the Great Lakes region by Heather Stirratt – Regional Coordinator for NOAA’s Coastal Services Center. Heather provided a clear overview of current trends and anticipated impacts of climate change in our region, and directed those interested to NOAA’s Digital Coast website to access the growing body of information on climate change and related issues -- www.csc.noaa.gov/digitalcoast/.

The symposium agenda built on the keynote address, encouraging increased awareness of effective ways to integrate climate change adaptation into ongoing wetland management activities. Sessions included *Linking Climate Change to Wetland Management; Habitat Restoration and Protection*; and *Climate Change and Water Management*. The symposium closed with a *Next Steps* session that set the stage for this white paper. Speaker presentations are available on the MWA Conference web page at www.miwetlands.org/. Major symposium sponsors included the NOAA Coastal Zone Program, Michigan Wetlands Association (MWA), Michigan Department of Environmental Quality (MDEQ), U.S. Environmental Protection Agency (USEPA), and the Association of State Wetland Managers (ASWM).

Collectively, these actions provide both an opportunity and a framework for developing and implementing a Climate Change Adaptation Plan for Coastal and Inland Wetlands in the State of Michigan. This report was developed for the Michigan Department of Environmental Quality, Wetlands Program and Coastal Management Program. However, the DEQ has only part of the responsibilities and authorities that will be part of any comprehensive approach to implementing a climate change adaptation plan for the state’s wetlands. Carrying out many of the recommendations in this document will require the cooperation, expertise and active engagement of many other state, local, and regional agencies and groups. Collectively this much larger partnership will need to review the recommendations in the report and reach agreement on specific actions that can be taken to ensure that wetland resources are included in broader strategies to address and adapt to climate change.

Predicted Changes in Temperature and Precipitation for Michigan

By the end of the century the climate change models predict the Great Lakes region will grow warmer and drier. This will mean a number of changes in Michigan weather.

- A 5-10 degree Fahrenheit rise in winter temperatures and a 7-13 degree Fahrenheit increase in summer temperatures are predicted.
- Extreme heat will be more common.
- Average precipitation levels are expected to remain relatively constant, but seasonal patterns will change with more precipitation in the winter.
- The higher temperatures will increase the evaporation resulting in a drier climate overall.
- The vegetation growing season will be 8-10 weeks longer.
- Time periods for Great Lakes and inland lake ice cover will decrease.
- In addition the frequency of severe weather events – flooding, droughts and heat waves – will increase.

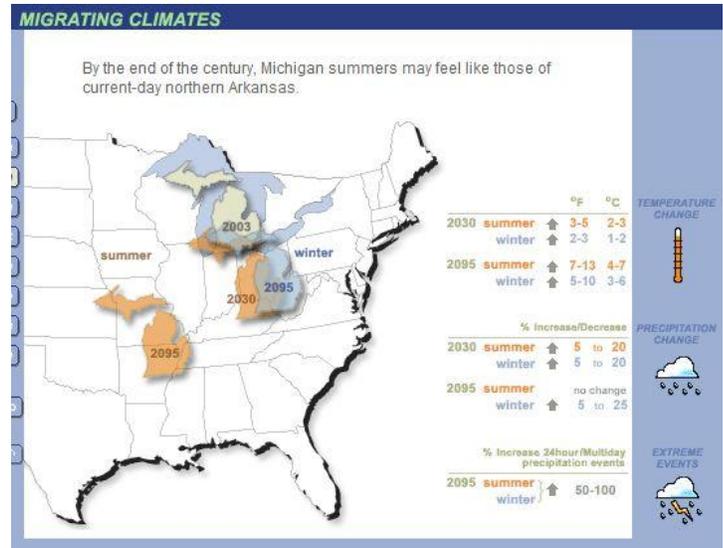


Figure 1 - Michigan Climate Migration - Source: Union of Concerned Scientists

Overall, the climate in Michigan is expected to change to resemble the current climate in Central Missouri and Northern Arkansas. There will be more water falling in the form of rain or snow during the dormant season (winter and spring) and less falling when it is needed during the summer months for plant growth (agriculture) and plentiful water (recreation, wildlife and drinking water). http://www.ucsusa.org/greatlakes/glregionmic_cli.html While there is a great deal of agreement among climate change scientists about global and regional long-term changes, there is uncertainty about the exact rates of change from year to year and local variability particularly over the next 100 years as the world’s climate goes through a period of instability to arrive at a new warmer ‘normal’ state worldwide.

Climate Change Impacts on Wetlands and Water Resources

The changes in climate will have a significant impact on water resources: the Great Lakes, rivers, streams, lakes, groundwater and inland and coastal wetlands. Impacts to one type of water resource will often have a ripple effect extending to other waters as well as other natural resources and Michigan citizens.

Wetlands – Drops in lake levels, earlier spring runoff, larger floods, and hotter summers are likely to have negative impacts to wetlands and the species that depend on them. Wetlands may disappear from this landscape or be altered and degraded by increased erosion from storm events, alterations in plant and wildlife composition through

appearance of invasive species and human actions. These changes in biodiversity and wetland structure could lead to a reduction in services provided by wetlands including flood storage, breeding habitats for birds and amphibians, and reduced water filtering and clean-up capacity. These in turn could lead to degradation of streams, lakes, and rivers where water quality is supported by the filtering capacity of wetlands. Wetlands exposed by lower Great Lake levels are likely to be under intense pressure for alteration through ‘beach grooming’ (wetland removal) activities undertaken by lakeshore owners. Forested wetlands may be affected by more frequent droughts and fires, and the introduction of new forest pests in response to warmer temperatures and shifts in species composition as the forest biomes shifts northward.

Great Lakes and inland lakes – Although it is not certain, most models predict that Great Lake levels will fall between 1 and 3 feet by the end of the century. That is, there is a great deal of certainty among climate change scientists that temperatures will get warmer. What is less certain is exactly how that change in temperature will influence precipitation patterns including timing and duration of rainfall and other important factors such as ice cover and evapotranspiration. Changing temperatures will lead to shifts in fish species, with coldwater populations decreasing in the southern parts of the Great Lakes while cool and warm-water species increase. The effects of the transition from cold to warmer water temperatures is likely to have a complex impact on cold water and niche species. Some species may be trapped and isolated in upper watersheds by warming thermal barriers. The same barriers already exist in the rivers between the Great Lakes. The St. Clair, Detroit and St. Mary’s Rivers are all warmer than the Great Lakes. Some fish may move into deeper colder lake waters. Changes in water temperature are likely to isolate, stress and reduce or even eliminate southern Great Lake coldwater fish populations over time.. Many invasive plant and animal species are likely to become more numerous either through introduction by man to a ‘friendlier environment’ or migration northward in response to warmer temperatures. Populations of habitat generalists, those species that are highly adaptable, are also likely to increase. Summer stratification in lakes may increase leading to more ‘dead zones’ which in turn can generate toxic algal blooms, bad-tasting drinking water and extensive fish kills.

Streams and Rivers – Hotter, drier summers will lead to smaller and warmer stream flows. Some streams may not flow in the summer. Increased flooding may occur in the winter and spring as a result of larger storm events. Collectively these can lead to erosion, alteration and degradation of stream habitat which will have a negative impact on fish and invertebrates. Streams will become flashier and more unstable, and many channels may move on the landscape, as a result.

Groundwater – Drier summers and lower water levels are likely to reduce groundwater recharge which will reduce flow to small streams and some wetlands. Drops in surface water levels are likely to increase groundwater withdrawals for agriculture and other uses which may lead to the loss of additional wetlands currently supported by groundwater. Michigan is already experiencing increases in the agricultural irrigation water withdrawals as a result of the dry, hot summer weather.

Wetlands as a tool to address the problems created by greenhouse gas emissions and adapt to climate change

Many wetlands and other water resources are likely to be negatively affected by climate change. So are terrestrial systems. Land uses such as agriculture, infrastructure for communities and recreational opportunities are also likely to see a negative impact. However wetlands also have enormous potential for reducing climate related impacts to agriculture, infrastructure, recreation and other highly valued sources of commerce if they are managed, restored and leveraged in ways that complement these activities. The goal must be to protect the surface and groundwater resources needed for farming practices, human infrastructure, and recreational activities, and reduce risks in the process. Wetlands perform many important ecosystem services that make them uniquely qualified to reduce the impacts of climate change on important sectors of Michigan's economy. They can be conserved and restored to improve the state's ability to protect and manage both the *quantity* and the *quality* of the state's waters ensuring that water is available when it is needed in appropriate quantities. Simultaneously this will provide habitat to sustain the state's rich wildlife and fishery resources. Wetland adaptation planning and implementation can not only protect and conserve wetlands but deliver ecosystem services that have high economic and social value as part of the state's overall climate change adaptation strategy.

The concept of increasing wetlands to adapt to climate change and to minimize negative effects is important because many traditional approaches to flood protection, water quality protection and water quantity management are predicated on the continued availability of cheap energy and petroleum based materials. If the cost of petroleum products increases dramatically, (as many predict it will) these solutions will be less cost effective. Leveraging natural systems such as wetlands to protect



groundwater supply for communities, sustain soil moisture for agriculture or reduce flooding and damage to infrastructure will be a cheaper, more sustainable solution. Also 'built' capital

deteriorates and loses value over time. Eventually it must be repaired and replaced. Well-managed ‘natural’ capital will sustain and even gain value over time. Many of the actions that can be taken to leverage wetlands to adapt to climate change are win-win solutions. These actions fall into the “no regrets” category of activities that is a popular component of climate change adaptation strategies.

Wetlands as a Resource to Conserve and Protect

Michigan’s landscape includes roughly 5.5 million acres of wetland, or 15% of the land area of the state. This represents about half the wetlands that existed prior to European settlement. Wetland types that occur within the state include emergent marshes, Great Lakes coastal marshes, deciduous and conifer swamps, bogs, fens, and headwater wetlands. 41 of the state’s listed threatened and endangered species of animals depend on wetlands and 49% of the state’s rare plant species are also dependent on wetlands.

<http://www.michiganltap.org/sites/ltap/files/workshops/materials/8%20Losee%20-%20Wetland%20Requirements.pdf> More information about rare and endangered species can be

found on the Michigan Natural Features Inventory website.

<http://mnfi.anr.msu.edu/explorer/search.cfm>

Great Lakes Coastal Wetlands

A detailed inventory of coastal wetlands by the Great Lakes Coastal Wetland Consortium completed in 2003 identified 275,748 acres of Great Lakes coastal wetlands in Michigan. The Inventory and Classification data in a GIS format is available for download on the Consortium web page - www.glc.org/wetlands. The acreage of wetlands on the Michigan coast is a decline from an estimated 369,000 that existed historically. Coastal wetlands are distributed throughout Michigan’s Great Lakes shoreline with 37% along Lake Huron, 28% along Lake Michigan, 16 % along the St. Clair River, 13% along Lake Superior and 6% along Lake Erie. Coastal wetlands are generally much younger than inland wetlands in the state. Glacial ice withdrew from Michigan 12,000 years ago, but the Great Lakes only reached their current levels less than 3,000 years ago. Coastal wetlands are subject to changing Great Lake water levels and do not mature to the same extent that inland wetlands do. Short term, temporary water-level fluctuations and long-term cyclic water level changes cause vegetation dieback, erosion and lateral displacements of vegetative zones which leads to the constant rejuvenation of coastal wetlands. (National Water Summary of Wetland Resources, USGS Water-Supply Paper 2425, 1996 p. 231)

Great lakes wetlands generally form in barrier-protected lacustrine environments or at the mouths of rivers and streams or the connecting channels of the Great Lakes. They include drowned river mouths, deltas, open embayments, open bays, dune and swale complexes, sand-spit embayments, and barrier beach lagoons.

http://www.michigan.gov/documents/deq/BetweenLandAndLake_339893_7.pdf

It will require extensive literature review as well as annual monitoring and observation of changes in wetlands to fully identify which wetlands and wetland dependent species are most at risk to changes that will occur as a result of climate change. However, two reports currently in preparation will contribute significantly to this effort. The Michigan Natural Features Inventory is completing a vulnerability assessment of Great Lakes coastal species in Michigan¹ (funded by the DEQ Coastal Management Program). The Michigan Department of Natural Resources has undertaken a parallel effort for inland species, with the exception of game fish.² Both vulnerability assessments take into account reliance on wetland habitat, but do not otherwise break out or rank wetland dependent species. Databases that are being developed through these projects will be useful in further analysis. The initial report is anticipated late in 2012.

Other strategies identify common wetland communities at risk are included in the recommendations section of the report, but it is possible to make some general observations about the vulnerability of wetlands and those general types likely to be least resilient and most threatened by climate change.

Wetlands are more sensitive to climate change than other landscape or deep water habitat types for three major reasons:

1. Flora and fauna in wetlands are more sensitive to changes in water levels than those of lakes, rivers, and streams. For example, lowering long-term water levels even a few inches can be the difference between a wetland or dry ground.
2. Wetlands have been cut off from other wetlands by dams, dikes, roads, and other alterations so wetland plants and animals cannot migrate to other wetlands in response to changes in temperature or water levels.
3. Mankind has already stressed wetlands which has reduced the biodiversity. Reduced biodiversity makes wetlands less robust and more vulnerable to small changes in temperature and water levels.

http://aswm.org/pdf/lib/11_carbon_6_26_06.pdf

¹ Lee, Y., M.R. Penskar, P.J. Badra, B.J. Klatt, D.L. Cuthrell, E.H. Schools, and C.L. Hoving. In Prep. Climate Change Vulnerability Assessment of Natural Features in Michigan's Coastal Zone, Final Report. Michigan Natural Features Inventory Report Number 2011-18. Lansing, MI.

² Hoving and Lee. In Prep. Which Species are at Risk from Climate Change, and Why? A Vulnerability Assessment of all SGCN and Game Species in Michigan. DNR Wildlife Division Report. Lansing, MI.

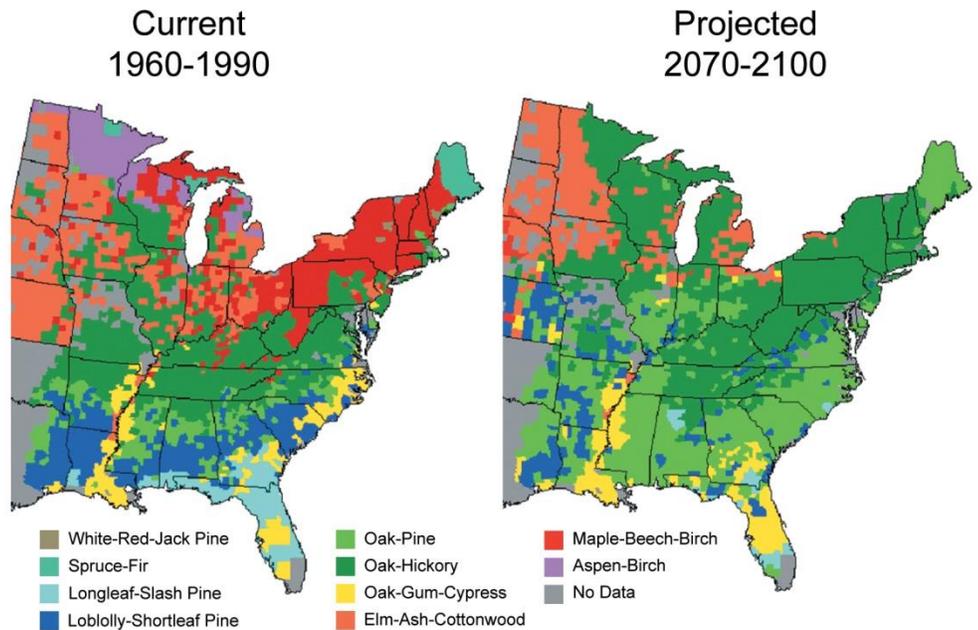
It is likely that some wetlands will disappear from the landscape or contract due to longer, hotter dry spells in the summer. Wetlands are also likely to change in species composition as a result of warmer temperatures that will favor migration of southern species into Michigan and create conditions inhospitable to some of Michigan’s existing wetland species. These changes may be gradual or dramatic. They may be permanent, or temporary, or cyclical. Given the significant increases in temperatures and changes in timing for precipitation it is unlikely that it will be possible to maintain the current species composition of many wetlands – both plants and animals.

Wetlands that are most vulnerable to changes in precipitation patterns will include depressional wetlands with small watersheds, boreal peatlands, and bogs which are all dependent to a large degree on the frequency and timing of precipitation as well as shallow or high groundwater wetlands such

as forested, shrub and fresh meadow, seasonal or temporary wetlands. Wetlands located in close proximity to areas of high nutrient and sediment runoff may be subject to higher levels of pollutant and sediment loading during larger and more severe storm events.

<http://profmandia.wordpress.com/2010/08/16/climate-change-impact-on-freshwater-wetlands-lakes-rivers/>

The longer growing season predicted for Michigan will extend the range of specific wetland species farther north into Michigan. Predicted changes in forest composition provide a case in point. The maple-beech- birch and aspen-birch forests of central and northern Michigan are expected to be entirely replaced by oak-hickory over the next century. This is not likely to be an orderly progression, but will occur through major cyclical events such as wildfires preceded or



NAST²¹⁹

The maps show current and projected forest types. Major changes are projected for many regions. For example, in the Northeast, under a mid-range warming scenario, the currently dominant maple-beech-birch forest type is projected to be completely displaced by other forest types in a warmer future.²⁴⁴

Figure 2- USGCRP (2009) Climate Change Impacts in the United States

followed by invasions of pests that attack forests already stressed by changing temperature and precipitation patterns. <http://www.epa.gov/climatechange/impacts-adaptation/forests.html>

Wetland species likely to be most at risk are those that are already identified as rare or endangered on federal or state lists. These wetland species are generally dependent on a special set of habitat requirements that are already rare. Climate change, specifically higher temperatures and more severe floods and droughts, is likely to stress and disrupt those special environmental conditions and many plants and animals have limited mobility and will not be able to migrate to new areas where appropriate conditions may exist. It is also likely that these changes will threaten populations of plants and animals that are currently common, but also unable to adapt to changing environmental conditions.



Greater resilience is expected for wetlands that are located in close proximity to a large water body. It is early to speculate, but the Great Lakes wetlands which are already adapted to cyclical changes may, with the implementation of good management practices, be among the more sustainable wetland types in Michigan. However, while these wetlands may be sustainable, it is still highly likely that there will be shifts in species composition in response to changes in temperature and precipitation.

In addition, the increased CO₂ concentrations are expected to have a direct fertilizing effect on plants. Plants respond to this with increases in net photosynthesis and water use efficiency which translates into greater productivity. Some plants are more responsive to increases in CO₂ (C₃ species) and some are less responsive (C₄ species) because they are already efficient. One simple prediction is the C₃ species will increase in abundance relative to C₄ species. But there are many variables and it is impossible to do more than anticipate that some wetland plants will respond to increased CO₂ with greater growth and productivity. <http://gallery.usgs.gov/videos/357>

Loss or Changes to Ecosystem Services Provided by Wetlands

A high percentage of Michigan residents recognize the multiple benefits provided by wetlands. Climate change is likely to make those services even more valuable while at the same time changes in temperature, precipitation and storm intensity and frequency have the potential to drastically reduce the services provided by wetlands. The impact of climate change on the services and goods wetlands provide for society will vary by type of wetland and by function/value.

Percent of Michigan residents who view various wetland services as very important or extremely important:

- **Wildlife habitat** **87%**
- **Fish habitat** **78%**
- **Flood control** **75%**
- **Wildflower habitat** **73%**
- **Water filtration** **73%**

- Michael D. Kaplowitz and John Kerr, Michigan residents' perceptions of wetlands and mitigation. *Wetlands*, Vol. 23, No. 2 June 2003

In recent years there have been a number of studies to quantify the value of ecosystem functions, which are also called ecosystem services and natural capital. For example, a study completed in 1997 concluded that the natural capital supporting human welfare had a value of \$33 trillion/year while the global gross national product totaled \$18 trillion per

year. (The Value of the World's Ecosystem Services and Natural Capital http://www.esd.ornl.gov/benefits_conference/nature_paper.pdf).

This study included an estimate of the value of wetland services which equaled almost \$15 trillion per year. Not all wetland types provide the same services, and this point was highlighted in the study which assessed value by broad categories of wetland types.

Location, morphology, soils and vegetation vary dramatically among wetland types and these variations lead to variations in services provided. For example, historically, declines in fisheries and waterfowl in the Great Lakes have been linked to losses of coastal wetlands.

Value of Wetland Services		
	Total value (US\$) per hectare per year	Total global flow value (US\$ per year)
Estuaries	22,382	4,100,000,000,000
Seagrass/algae beds	19,004	3,801,000,000,000
Coral reefs	6,075	375,000,000,000
Tidal marsh/mangroves	9,990	1,648,000,000,000
Swamp/floodplains	19,580	3,231,000,000,000
Lakes/rivers	8,498	1,700,000,000,000

Figure 3 - Adapted from R. Costanza et al, 1997 "The Value of the World's Ecosystem Services and Capital," *Nature*, Vol. 387. <http://www.biology.duke.edu/bio217/2002/jah5/valuation1.htm>

http://www.michigan.gov/documents/deq/BetweenLandAndLake_339893_7.pdf Great Lakes wetlands also provide shoreline stabilization, aesthetics and green space. Below is a list of ecological services provided by wetlands in Michigan and an analysis of how these might be impacted by climate change.

Fisheries production. With rising water temperatures in lakes, streams and wetlands, reductions in the numbers of coldwater fish (e.g., sturgeon, whitefish) and increases in warm water fish such as bass may be expected. With changes in Great Lake water levels it will be necessary to allow migration of coastal wetlands up and down gradient or additional

losses in fish populations which depend on wetlands for rearing or food chain support may also be expected. Currently research is being conducted by Stuart Ludsin at The Ohio State University on this topic. <http://changingclimate.osu.edu/people/stuart-ludsin/> A webinar summarizing some of his work on climate change can be found at: <http://changingclimate.osu.edu/webinars/archives/2011-04-19/>

Waterfowl production. Increased temperatures with little change in total precipitation will convert some wetlands to dry land, reduce others in size, and shift marshes with standing water to saturated soil wetland types (e.g., shrub or forested wetlands). Changed water regimes during the spring and fall may adversely affect waterfowl even if total precipitation remains constant. With the potential loss of the Prairie Potholes, the duck rearing factory to the West, wetlands in Michigan and Great Lake coastal wetlands may become even more important to the support of waterfowl populations. On the other hand, changes to Michigan wetlands may also reduce breeding habitat and cause shifts in migratory species. For example Canada geese may winter further north. For additional information, see the USDA Forest Service publication, *A Climate Change Atlas for 147 Bird Species of the Eastern United States* (<http://www.nrs.fs.fed.us/atlas/bird>).

Habitat for rare and endangered species. The importance of wetlands for rare and endangered species in Michigan has been mentioned earlier. Successful reproduction may be compromised for species that are dependent upon specific hydrologic and temperature conditions, particularly where these flora and fauna cannot migrate to new locations. This is even more true for flora and fauna dependent on wetland habitats that are already stressed by water pollution and human-induced fragmentation. Wetland losses and changes in flood pulses will likely reduce breeding sites for amphibians and migratory shore birds. Species extinctions and biodiversity loss are probable. Species range and ecosystem structure will also change. Further challenges due to invasions by some southern species extending their range northward (and potentially losing it southward) are also likely.

Food chain support. Destruction of coastal wetlands by changes in Great Lake levels may result in loss of detritus and other food chain support for lake fish populations and other fauna. Similarly, destruction or reduction in the size of slope, depressional, flats, and some river and inland lake fringe wetlands due to a combination of increased temperatures and/or changes in precipitation patterns could reduce food chain support for not only wetland species but for river, lake, and upland birds and animals which depend upon wetlands as a source of food. On the other hand, some increase in food chain support might be expected in some situations due to increased primary productivity resulting from increases in CO₂.

Water quality buffering and pollution control. Destruction of coastal wetlands due to lake level changes could result in loss of their water quality pollution control functions. Similar losses would occur where depressionnal, slope, flats, and river and inland lake fringe wetlands are diminished in size or destroyed by lowered ground or surface water elevations due to reduced precipitation and/or increased temperatures. On the other hand, some increase in water quality buffering could occur for freshwater wetlands due to CO₂ induced increases in the density and amounts of vegetation. Some wetlands would increase in size during periods of more intense rainfall leading to larger fluctuations in their size on an annual basis.

Wave attenuation and erosion control. The destruction of coastal wetlands by lake level changes would expose coastal areas to winter storm winds and waves. However, the increased density of wetland vegetation due to increased CO₂ might also enhance the wave attenuation and erosion control functions of surviving coastal and inland freshwater wetlands.

Production of forestry products and natural crops. Increased CO₂ may result in increased growth of trees and other natural wetland crops such as wild rice and cranberries if such increases are not “limited” by phosphorus, nitrogen, or other limiting factors. Conversely, there could also be a reduction in the availability of coastal and inland freshwater wetland crops and forested wetland products from severe storms, droughts, heat stress, wildfires and pest infestations.



Flood conveyance and flood storage. The flood conveyance and flood storage roles of wetlands for major flood events would probably not be substantially affected by climate change since these roles depend more upon wetland configuration and size than biotic factors. However, increased vegetation growth due to increases in CO₂ might reduce flood conveyance capacity for riverine wetlands by increasing the “roughness” of wetland-dominated floodplains. Sediment loadings due to increased severe meteorological events could also fill depressionnal, riverine and other wetland types with resulting reduction in flood conveyance and flood storage capability

http://aswm.org/pdf/lib/11_carbon_6_26_06.pdf.

Carbon storage and sequestering. Increased CO₂ could result in increased plant growth in wetlands and the potential for increased carbon sequestration where there are no other limiting factors. In fact recent research conducted by Dr. William Mitsch of The Ohio University found that freshwater wetlands in temperate areas such as Michigan, particularly recently restored wetlands are significant carbon sinks. Existing wetlands such as peatlands hold major stores of carbon which could be adversely impacted by climate change and should be managed to prevent release of carbon dioxide and other atmospheric gases. <http://researchnews.osu.edu/archive/freshwetlands.htm>

The role of wetlands in sequestering and releasing greenhouse gases is complex. Wetlands are huge repositories of carbon worldwide an estimated 500-700 GT globally which is similar in magnitude to the total amount of atmospheric carbon.

http://aswm.org/pdf_lib/afwa_biological_carbon_sequestration_white_paper.pdf Right now carbon emitted from arctic and tropical peatlands is the source of 6% of the global climate emissions—the result of changing climate and drainage for forestry and agriculture. Both dry out these huge carbon reservoirs releasing the carbon into the atmosphere.

There has been a significant amount of debate over the pros and cons of using wetlands for carbon storage. It has been almost entirely based on research directed to arctic and tropical peatlands with little focus on freshwater temperate wetlands including depressional forested wetlands (swamps). In Michigan protecting existing carbon stores in wetlands and restoring wetlands to create new carbon stores provides a significant opportunity to pursue reduced greenhouse gases.

Groundwater Recharge. The relationship between wetlands and groundwater is complex. Some wetlands provide groundwater recharge; others are sites for groundwater discharge. Some wetlands are perched and isolated from groundwater and other wetlands provide both recharge and discharge functions under different climate conditions. Changes to wetlands in response to climate change may also be a surface indicator of changes in groundwater availability. Many of the climate change impacts are likely to reduce groundwater recharge. Warmer temperatures mean more evaporation and less groundwater recharge. Higher precipitation in the winter and early spring and less in the summer will reduce overall groundwater recharge due to a combination of lower summer precipitation, higher summer evaporation, higher flows in the winter/early spring which can exceed soil infiltration capacity and larger winter storm events occurring when air temperatures are cold and/or the soil is frozen further reducing groundwater recharge.

<http://expeng.anr.msu.edu/uploads/files/20/Climate%20Change%20Implications%20for%20MI%20by%20Dr.%20David%20Lusch.pdf> <http://iahs.info/redbooks/a044/044030.pdf> Hotter, drier summers will lead to more groundwater extraction for agriculture (crops), municipal and

private drinking water supplies. Restoring and conserving wetlands and managing surface water including precipitation runoff to maximize groundwater recharge is likely to yield cleaner, more plentiful water supplies for Michigan citizens and the state's economy.

Wetlands as a Tool to Mitigate for and Adapt to Climate Change

Climate change is expected to affect wetlands and some of those impacts will be very significant. However, the ecosystem services provided by wetlands are important as well. It will be important to consider.

“What ecosystem services do wetlands provide to mitigate climate change and how can coastal and inland wetlands be managed to provide more of those services in the future to counteract and reduce (mitigate) the negative effects of climate changes?”

The previous section described the ecosystem services provided by wetlands. In the absence of human intervention to conserve, protect and restore wetlands, many of these services could be severely compromised or lost. However, they can also be supported and focused in areas where they are needed through human intervention. Coastal and freshwater wetlands can be managed to adapt to climate change in a manner that protects the quality of other aquatic resources. They can provide flood storage through reducing the impacts from larger storm events. Wetlands can support retention of soil moisture required by agriculture as well as food and forest product production. They can provide refugia and corridors for movement of desirable flora and fauna including waterfowl and fisheries. But they can only provide these benefits if they are actively managed with a goal towards maintaining and expanding ecosystem services to adapt to climate change. For example wetlands can be protected and restored to store floodwaters during heavy precipitation events so they are available later in the year to support soil moisture and groundwater recharge. Wetlands restored on mineralized soils store large amounts of carbon offsetting greenhouse gas emissions. Wetland vegetation can be managed to support wildlife populations impacted by climate change. Wetland plants grow quickly and in the future may become a source of biofuels.

This perspective also has the advantage of helping the public understand the importance of protecting and increasing the ecosystem services provided by wetlands as part of broader adaptation efforts. It will be essential to provide information to decision makers and the general public to help them make the link between 1) ecological services provided by wetlands, 2) the potential elimination of many of these services without a plan to undertake active measures to support adaptation to climate change and 3) the benefits of having a plan. Specifically, wetland adaptation activities should be described as measures to take to manage, conserve and protect coastal and inland wetlands to adapt to climate change in order to support:

1. Water quantity management – flood storage, groundwater storage, etc.
2. Water quality protection – filtering out pollutants as part of buffering against increased storm runoff and larger precipitation events
3. Hazard management – shoreline stabilization, storm surge buffering
4. Habitat/wildlife protection – including sustaining habitat corridors and maintaining biodiversity, and
5. Carbon sequestration – reducing greenhouse gases.

In many cases individual wetlands can provide two or more of these services making wetlands and other natural resource climate change adaptation options much more cost effective than many of the more commonly-used, constructed, single-purpose approaches such as flood control structures and stormwater detentions basins. An ecosystem services approach to quantifying the multiple benefits of protecting, managing and restoring wetlands proactively is likely to lead to cost savings by accomplishing several benefits with one project.

Strategic Approaches

The Michigan Climate Action Council Climate Action Plan provides an overall framework for Michigan’s response to climate change. It sets greenhouse gas (GHG) reduction goals and makes recommendations for various sectors of the state’s economy. The most relevant sections of the report for insight into how a wetland adaptation plan can complement the state’s climate action plan are found in Chapters 7 and 8: Agriculture, Forestry and Water Management Sectors and Cross-Cutting Issues. http://www.michigan.gov/documents/deq/deq-miclimateactionplan-part1_276563_7.pdf Specific areas where wetland adaptation and more specifically maintenance and improvement in wetland ecosystem services could support achievement of policy recommendations include these areas:

AFW-5. Promote Continuous Vegetative Cover

AFW-6. Forestry and Agricultural Land Protection

AFW-7. Promotion of Farming Practices That Achieve GHG Benefits

AFW-8. Forest Management for Carbon Sequestration and Biodiversity

CCI-8. Adaptation and Vulnerability

CI-10. Enhance and Encourage Economic Growth and Job Creation Opportunities through Climate Change Mitigation

CCI-11. Enhance and Encourage Community Development through Climate Change Mitigation: Address Environmental Justice

In addition the Michigan Department of Environmental Quality Michigan Coastal Management Program included a chapter on Climate Change Adaptation in Coastal Wetland Management in the “Section 309 Assessment and Five-Year Strategy for Coastal Zone Management Program Enhancement Fiscal Years 2012-2016” <http://www.michigan.gov/documents/deq/deq-ogl-mcmp->

[Section309Strategy2012-2016_369789_7.pdf](#) includes a chapter: “Climate Change Adaptation in Coastal Wetland Management.” It includes the following recommendations (pp. 67-71).

- *Identify adaptation measures and strategies for addressing [climate change] impacts that are appropriate for Michigan’s coastal wetlands, and suited to Michigan’s state and local wetland protection and management framework.*
- *Identify adaptation actions that will maintain or expand overall biodiversity, increase connectivity of coastal wetland areas, and improve water management to address multiple natural resource goals are priorities.*
- *Work with other agencies and organizations that provide land use planning assistance to local governments to develop technical assistance on incorporating climate change adaptation measures for coastal wetlands in local green infrastructure plans, land use plans, and zoning ordinances.*
- *Revise current regulatory processes to integrate climate change adaptations into the permitting, enforcement and mitigation decision making processes.*
- *Incorporate the most up-to-date climate change information into Michigan’s Climate Action Plan, Wetlands Action Plan, Wildlife Action Plan, and CELCP Plan to guide State agencies in program and policy decisions.*

Collectively these along with other recommended policies and program actions in the strategy provide a starting point for developing detailed recommendations for a wetland adaptation plan.

Wetland Adaptation Planning in Other States

In 2010 the Association of State Wetland Managers gathered information about climate change adaptation activities in other states, particularly those plans that included wetlands. At that time six states were identified with climate change adaptation plans that included wetlands, such as California, Colorado, Florida and Maryland. Six more states were in the process of developing adaptation plans that included wetlands: Alaska, Connecticut, Minnesota, Vermont, Washington, and Wisconsin. Since 2010 some plans, such as Wisconsin’s have been completed. The summary of state efforts by ASWM along with links to completed plans and state contacts is available at: <http://www.aswm.org/wetland-science/climate-change/climate-change-adaptation/1200-climate-change-adaptation-summaries> Below are some highlights from other state adaptation plans.

Maryland

The purpose of Maryland's state adaptation plan is to reduce Maryland's vulnerability to climate change. Goals for natural resource protection include retaining and expanding forests, wetlands and beaches to protect from coastal flooding with the following targets:

- Expanding priorities for existing land conservation to promote horizontal marsh migration or vertical accretion, where feasible.
- Expanding financial incentives that encourage private forest and waterfront and riparian landowners to favor the retention of forests and other native habitats over development and conversion.
- Managing forests and wetlands to enhance ecological services and storm impact reduction benefits.
- Identifying and developing programs to enhance and protect wildlife corridors and maintain connectivity of green forest core areas across the landscape.
- Reorienting DNR's Shoreline Conservation and Management Program to promote the installation of innovative shore protection techniques that maximize habitat restoration and enhancement and accommodate for projected sea-level rise.
- Developing a general permit that streamlines the rebuilding process of storm-damaged tidal marshes, including the placement of additional clean sandy fill, plants, and temporary, biodegradable structures to protect rebuilt areas.
- Directing a joint effort of state agencies to standardize design and construction methods and protocols employed for new, retrofitted, or replacement shore erosion control structures that consider climate adaptive strategies for coastal environments subject to sea-level rise, erosion, and storm hazards.
- Integrating mapping and modeling products into state and local planning and implementation efforts.
- Updating the Maryland Comprehensive Shoreline Inventory to include type and quantity, location, and conditions of shore erosion control structures on a routine basis, possibly every 5–10 years.

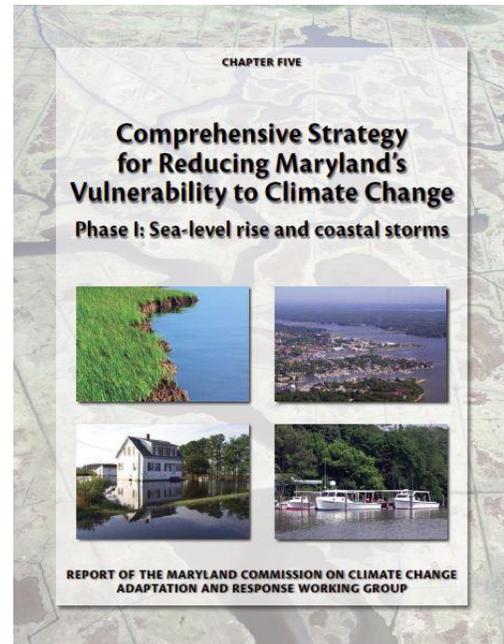


Figure 4 - Maryland Climate Change Strategy

- Expanding current outreach and educational programs directed at the public and marine contracting professionals to help ensure a smooth transition toward broader implementation of non-structural and hybrid techniques.

<http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>

California

California has a comprehensive climate change strategy that integrates recommendations for wetlands into actions to address biodiversity, coasts and oceans and public health. In the section on Water [http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy - Chapter 7 - Water Management.pdf](http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy_-_Chapter_7_-_Water_Management.pdf) the following actions are identified:

Strategy 5: Enhance and Sustain Ecosystems

Long-Term and Near-Term Actions:

Species Migration and Movement Corridors – Water management systems should protect and reestablish contiguous habitat and migration and movement corridors for plant and animal species related to rivers and riparian or wetland ecosystems. IRWM and regional flood management plans should incorporate corridor connectivity and restoration of native aquatic and terrestrial habitats to support increased biodiversity and resilience for adapting to a changing climate.

Floodplain Corridors – Flood management systems should seek to reestablish natural hydrologic connectivity between rivers and their historic floodplains. Setback levees and bypasses help to retain and slowly release floodwater, facilitate groundwater recharge, provide seasonal aquatic habitat, support corridors of native riparian forests and create shaded riverine and terrestrial habitats. Carbon sequestration within large, vegetated floodplain corridors may also assist the state in meeting GHG emissions reductions mandated by AB 32.

Anadromous Fish – The state should work with dam owners and operators, federal resource management agencies, and other stakeholders to evaluate opportunities to introduce or reintroduce anadromous fish to upper watersheds. Reestablishing anadromous fish, such as salmon, upstream of dams may provide flexibility in providing cold water conditions downstream, and thereby help inform system reoperation. Candidate watersheds should have sufficient habitat to support spawning and rearing of self-sustaining populations.

Tidal Wetlands as Buffers – The state should identify and strategically prioritize for protection lands at the boundaries of the San Francisco Bay and Sacramento-San Joaquin Delta that will provide the habitat range for tidal wetlands to adapt to sea-level rise. Such lands help maintain estuarine ecosystem functions and create natural land features that act as storm buffers, protecting people and property from flood damages related to sea-level rise and storm surges.

Reversal of Delta Island Subsidence – The state should prioritize and expand Delta island subsidence reversal and land accretion projects to create equilibrium between land and estuary elevations along select Delta fringes and islands. Sediment-soil accretion is a cost-effective, natural process that can help sustain the Delta ecosystem and protect Delta communities from inundation.

Upper Watershed Services – The state should consider actions to protect, enhance and restore upper watershed forests and meadow systems that act as natural water and snow storage. This measure not only improves water supply reliability and protects water quality, but also safeguards significant high elevation habitats and migratory corridors.

Minnesota

Minnesota has extensive peatlands and many of these have been altered over time. Alteration of peatlands, particularly activities that dry out these lands make them a source of CO₂ and other greenhouse gases. Minnesota DNR is working toward changing management of peatlands so that they are a carbon sink rather than a source for greenhouse gases. The state is undertaking research studies to gain a better understanding of how to implement this goal successfully including:

“Peatland Carbon Sequestration” study proposal:

http://www.aswm.org/pdf_lib/peatland_carbon_sequestration_LCCMR_proposal.pdf

and

“Carbon Burial in Wetlands” study proposal:

http://www.lccmr.leg.mn/all_projects/2010_projects/work_programs_may/subd_3g_work_program1.pdf

In addition Minnesota has established outcomes and key measures to track the state’s progress.

Long term desired outcomes

- DNR, stakeholders and partners expand and share their knowledge of climate change impacts and work together to identify adaptive management strategies for natural lands and water.
- Natural lands sequester carbon to mitigate climate change while providing habitat and other co-benefits.
- 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.
- Minnesota's natural lands and waters are resilient to climate change so that they continue to provide significant ecological, recreational, and economic benefits.

Key measures to evaluate progress

(Detailed descriptions of these and other measures are found in DNR's Strategic Conservation Agenda: Part II - Performance and Accountability Report.)

Carbon Inventory: Acres of DNR-administered lands that have carbon stocks inventoried according to protocol (indicator in development)

Carbon storage and flows: Tons of carbon sequestered and emitted on DNR-administered lands (indicator in development)

Mitigation and Adaptation Planning: Percent of DNR management plans with comprehensive strategies for climate change mitigation and adaptation (indicator in development)

Figure 5 - Minnesota Outcomes and Key Measures

http://www.dnr.state.mn.us/conservationagenda/direction/climate_change.html

Each state adaptation strategy takes an approach tailored to address the challenges specific to their respective state in ways that are logical in the context of both the state's resources and the organization of state agencies and programs. Other state adaptation plans provide some useful ideas about how Michigan might use and revise their state's strategies to address challenges and solutions unique to the state. One useful reference for learning how other states are responding to climate change can be found on the National Resources Defense Council Website: Ready or Not: How Water-Ready is your State or City? <http://www.nrdc.org/water/readiness/>

Recommended Actions

Climate change provides formidable challenges for the state of Michigan and for the conservation of its natural resources including wetlands. Over time it is likely that new initiatives and programs will be needed, but there are also significant opportunities to adjust and tailor existing restoration, regulation, resource management, planning, training, monitoring and mapping programs to address climate change adaptation. Leveraging existing programs is also likely to support identification of those actions that are categorized as "no regrets" policies, i.e., opportunities within existing programs that provide greater capacity for dealing with problems associated with climate change but don't impose significant new costs or diverting economic activity. Nationally and internationally there has been a great deal of support for 'no regrets' options that create benefits no matter how the climate changes in the future even if those changes are larger or smaller than predicted.

The recommendations below are organized under five major headings: 1) Advance Strategic Planning 2) Monitoring and Assessment, 3) Voluntary Restoration, Conservation and Management 4) Regulations and 5) Integration with Other Water Programs for Watershed Management. The last four are further subdivided into a) General, b) Coastal Great Lake Wetlands and c) Inland Wetlands.

1. Advanced Strategic Planning

This white paper outlines a wide range of potential actions to address climate change adaptation. A more in depth and focused consideration of priority topics is needed to set a statewide direction, and to avoid working at cross purposes. The definition of broad goals and policies will of necessity include a number of atypical partners.

Water management has an impact on all of the important economic interests in Michigan – agriculture, tourism, urban development, and protection of private property from flooding and storms. Wetlands are likely to play a key role in meeting the multiple needs of these interests, offering a “no-regrets” opportunity to address climate change in a positive manner, and to work with these various stakeholder groups to address management of both surface and groundwater resources.

Future **management of Great Lakes coastal areas** in particular is a complex issue – stakeholders may have significantly different goals for management of coastal wetlands during a decades long period of change and uncertainty. It is therefore advisable to establish an ongoing forum to develop strategies that are the most widely acceptable.

Climate change will also require a new perspective on **invasive species management**. The migration of species to follow climate change patterns is expected to result in the identification of multiple new species – some of which represent early stages of succession and others that are nuisance species taking advantage of disturbance. The responses to these community shifts will require new approaches. Aquatic species are by nature more limited in distribution patterns. There are limited avenues for migration from areas south of the Great Lakes basin, and it is likely that many if not most aquatic invasives will arrive through human activities (including ballast water, and through artificial connections with other river basins). Given the limited ability of invasives to migrate elsewhere, it is also especially critical that habitat necessary to support fish and other aquatic species be maintained or expanded to the extent possible. Wetland habitats are used by a high percentage of wildlife species at some point during their life cycle.

Recommendation – An overall response to changing hydrologic conditions should be discussed by scientist and policy makers from environmental, fish and wildlife, and agricultural agencies, together with local government agencies responsible for water management – including County

Drain Commissioners, and those responsible for management of stormwater and drinking water. An overall goal of “keeping the water on the land” should be discussed. Providing increased water storage in wetlands, vegetated floodplains, and similar natural areas will limit the potential for increased flooding, while encouraging groundwater recharge and maintenance of stream baseflow. Given the likelihood of increased drought conditions, this water supply will be critical for agricultural interests.

Use of natural “green infrastructure” will also serve the goal of preserving or expanding wildlife corridors, and filtering runoff to protect water quality downstream.

Ideally, a statewide policy agreement regarding future water management should be sought.

Recommendation – The Michigan Climate Action Council Climate Action Plan identifies a number of areas of activity where wetlands conservation and restoration actions could enable the state to adapt to climate change through “no regrets” policies and actions. Michigan DEQ and other collaborative interest groups should jointly review the specific strategies and actions identified in Michigan’s Climate Action Plan and identify specific opportunities to conserve, protect and restore wetlands to achieve plan objectives. See Appendix A – Wetland Management Measures Supporting Climate Change Adaptation. Promising areas include but are not limited to the following recommendations in the final report:

AFW-5. Promote Continuous Vegetative Cover

AFW-6. Forestry and Agricultural Land Protection

AFW-7. Promotion of Farming Practices That Achieve GHG Benefits

AFW-8. Forest Management for Carbon Sequestration and Biodiversity

CCI-8. Adaptation and Vulnerability

CI-10. Enhance and Encourage Economic Growth and Job Creation Opportunities through Climate Change Mitigation

CCI-11. Enhance and Encourage Community Development through Climate Change Mitigation: Address Environmental Justice

Recommendation – There is a natural tendency for citizens, elected officials and project managers to resist change and attempt to maintain the status quo. This will also be true for wetland and wildlife and water resource managers who are likely to look first to strategies and actions designed to keep existing natural resources intact. This is unlikely to be a realistic approach to dealing with climate change. The 2011 Symposium on Wetland Management in Response to Climate Change provided an opportunity for focused discussion on wetlands and climate change. As a follow-up Michigan DEQ in partnership with other collaborators should host a workshop or perhaps a series of workshops with climate change scientists and wetland, wildlife, hydrology, and meteorology experts to evaluate the feasibility of possible responses to climate change under different management scenarios such as 1) measures required to allow only minimal change to wetlands habitats and associated resources, 2) measures required for moderate change 3) measures required

to facilitate and support changes (i.e. embrace and accelerate changes to wetlands and other natural resources occurring as a result of climate change. The purpose of this discussion is to fully explore the expense effort and likely outcomes of managing toward different endpoints. This is an approach similar to when a community explores no growth, moderate growth and accelerated growth futures in terms of costs and benefits. Publish a report of the findings of the workshop(s).

Recommendation – In collaboration with multiple interest groups, continue to address issues of Great Lakes coastal management in light of uncertain future conditions including changing water levels, water temperatures and precipitation patterns. Maintenance of vegetated wetlands will be critical not only for fish and wildlife habitat, but to protect coastal areas from more significant storm events, and to protect water quality. It is expected that coastal property owners will continue to seek open beaches if water levels recede, putting vegetated areas at risk. Ongoing dialogue will be needed to reach agreement on the scope of existing vegetated areas, means to protect critical wetland habitat and protection of shoreline under future conditions.

Recommendation – Coastal management agencies – including those responsible for management of state public trust bottomlands, land use planners, and local units of government should consider development of new model approaches to management of shorelines during a period of change and uncertainty. It may be appropriate to develop methods for rolling easements that ensure protection of bottomlands during a period of change. Consideration should be given to lease of bottomland easements that will ensure maintenance of vegetated habitat as well as open shoreline areas in the event of significant future changes in lake levels, while providing for rights of current coastal property owners. For more information on rolling easements see: www.epa.gov/cre/downloads/rollingeasementsprimer.pdf



Recommendation – Research should be conducted on current and possible future invasive species to better evaluate the ecosystem functions of newly introduced flora and fauna. Invasions of plants may indicate other issues within wetlands and aquatic systems such as compaction or soil mineral imbalances, changes in local conditions, etc. Some invasive species may serve as early successional species. Others may not persist over time. Research should prioritize threats and provide a basis for management strategies.

Recommendation – Revise Michigan’s Aquatic Invasive Species Management Plan to anticipate climate change related migration of species from southern biomes. Plan revisions should evaluate the potential for both human (i.e., boat ballast) and natural (birds, seed dispersal) introductions.

Likely pathways, identification of flora and fauna expected to migrate north, and methods to evaluate the acceptability of species should be included. Climate change makes it very difficult to predict both specific species and the timelines of possible introduction in advance. This portion of the plan should be revised on a regular basis in response to improvements in climate change modeling and real time measurement of changes presence and migration of invasive species.

2. Monitoring and Assessment

The Michigan DEQ has developed a comprehensive water assessment and monitoring program (2005 update of the Water Quality Monitoring Strategy) as well as a separate Wetland Monitoring and Assessment Strategy (also completed in 2005). Other state, federal and local agencies and academic institutions also conduct a significant level of monitoring and assessment of Michigan's waters, ecosystems, and wildlife. To date, monitoring directed specifically at climate change evaluation has been more limited. It is likely that a significant amount of information can be extracted from current monitoring efforts to evaluate many of the impacts of climate change on wetlands and associated resources.

General recommendations

Recommendation – Identify sources of continually updated information about climate and related status and trends that can be used to measure changes in climate in the state of Michigan. Changes in average temperatures, precipitation, ice and snow cover, water levels, changing vegetation patterns and other information that is collected regularly and indicative of changes in climate should be collected and displayed in a GIS format. This should be displayed on the internet for program managers, elected officials and Michigan citizens.

Recommendation – Establish long-term desired outcomes and metrics to identify progress, (similar to Minnesota) to measure progress adapting to climate change. Minnesota has established a series of key measures which include “indicators” and “targets” for performance areas including waters and watersheds, natural lands, fisheries and wildlife, outdoor recreation and organization effectiveness. http://www.dnr.state.mn.us/conservationagenda/key_measures.html

Recommendation – Conduct a literature review and interview wetland managers and scientists to establish a list of the wetland types as well as individual flora and fauna most threatened by climate change. In addition Michigan Natural Features Inventory is conducting vulnerability assessments of natural communities, including wetlands, as well as many plant and animal species. Future natural communities are likely to be different from those that exist currently and this information will also aid managers in understanding whether plant communities do change as predicted and make appropriate adjustments to management plans based on whether they do or do not.

Recommendation – Adapt existing wetland monitoring programs to document changes in wetland communities over time. In the coming decades there is a great deal of uncertainty with respect to how and when climate change will occur. This makes it difficult to develop plans to respond to climate change. In the absence of certainty, it will be necessary to plan for uncertainty and be prepared to make changes in wetland programs and policies as changes are documented. Michigan DEQ already has established a series of reference sites for wetlands. These provide a baseline for the current status of wetlands to measure against. MDEQ should convene a meeting of the monitoring, assessment and research community to develop a plan for using reference sites to track climate change impacts to wetlands.

Recommendation - Incorporate the most up-to-date climate change information into Michigan's Climate Action Plan, Wetlands Action Plan, Wildlife Action Plan, and CELCP Plan to guide State agencies in program and policy decisions. The exact path climate change will take as temperatures warm is not predictable and this will increasingly require state and local government to adapt to new information as it becomes available. State and local governments must develop the ability to make adjustments to existing programs with little lead time. The purpose of each of these plans is different and the amount and kind of information about climate change in them will vary, but all should help direct state and local agencies to make appropriate changes in response to new information on climate change.

Recommendation – Document and communicate success or failures of implementation of wetland protection, restoration and management actions to adapt to climate change in an annual report.

Coastal Great Lakes Wetlands

Recommendation – In cooperation with coastal wetland specialists, consider the use of data collected through ongoing coastal wetland monitoring (including GLRI funded coastal wetland monitoring) to establish a clear baseline for coastal wetland condition. Integrate this information with current climate science to real time and potential future changes to coastal wetlands. Revise as new information becomes available.

Recommendation – Review published literature and interview coastal wetland research and management experts to refine and improve understanding of specific climate change impacts to Great Lakes coastal wetlands. Identify research gaps. Publish a report of findings and distribute to state and federal agencies and Academia.

Inland Wetlands

Recommendation – In cooperation with scientists, who supported development of wetland assessment procedures in Michigan, determine the extent to which existing assessment methods can be used to track the impacts of climate change. Refine data collection for tracking changes in climate to provide more detailed information about what is occurring in inland wetlands. Integrate this information with current climate science to real time and potential future changes to inland wetlands. Revise as new information becomes available.

Recommendation – Review published literature and interview inland wetland research and management experts to refine and improve understanding of specific climate change impacts to inland wetlands. Identify research gaps. Publish a report of findings and distribute to state and federal agencies and Academia.

3. Voluntary Restoration, Conservation and Management

Wetland preservation, restoration and stewardship by private landowners and public land management agencies predates wetland regulation. Wetland conservation activities are driven by desires for improved habitat, open space, water quality protection, and other concerns. Fortunately, the continuation of these conservation programs will also provide real benefits for adaptation to climate change. Thus, continued emphasis on restoration and conservation provides a no-regrets approach to climate change adaptation that will provide positive benefits for Michigan's resources regardless of the extent of climate change impacts.

Integration of climate change adaptation criteria into multiple conservation programs will further this approach.

General

Recommendation – Develop a state GIS database that provides the ability to do multiple analyses for leveraging wetland restoration, management and protection to provide ecosystem services and mitigate the impacts of climate change. This can include identifying both existing wetlands, and possible wetland restoration sites, with an increased focus on climate adaptation needs. DEQ has already done preliminary work identifying potential wetland restoration sites based on historic conditions and current land use. Additional information is needed regarding existing and potential wildlife corridors; wetlands and other water bodies at risk in a drier climate; projected changes in wetland types as a result of climate change, etc. For example the state is currently developing LLWW classifications for the Nonpoint Source Program in parts of the state that could also provide general information about potential services provided by individual existing or restored wetlands, and could be further refined to address climate change issues. Soils wetness information

can provide information about sensitivity to hotter, drier summers, and there are other existing GIS layers or layers under development that could provide additional information. One example is the Yaquina estuary conservation plan developed by The Wetlands Conservancy in Oregon. The plan and accompanying atlas (GIS analysis) can be found at http://oregonwetlands.net/index.php?option=com_content&view=article&id=75&Itemid=79

Recommendation – Identify programs and other opportunities to support conservation and restoration of wildlife corridors to support movement of desired fauna and flora in response to climate change.

Recommendation – Floodplain Plans should support restoration of wetlands and other aquatic habitats to provide flood storage, improve water quality and support biodiversity. Michigan DEQ should confer with the State floodplain management program to determine whether this has been adequately addressed in existing plans or opportunities for improvement exist.

Recommendation – Carry out wetlands restoration and protection demonstration projects that are identified through the planning and GIS analysis recommendations above.

Recommendation – There are significant stores of carbon and other Greenhouse Gases in existing wetlands such as undrained peatlands and fens. Characteristics of wetlands with significant stores of wetlands within Michigan should be identified and described and DEQ should work with Land Trusts and other local nonprofits to protect wetlands with significant carbon stores. Management measures that protect carbon stores should be identified. These may include actions such as ensuring these areas are not drained or management actions such as rewetting if there are climate induced changes in hydrology

Coastal Great Lakes Wetlands

Recommendation – Identify opportunities for land management and conservation programs to promote protection of coastal wetlands as lake levels changes. There may be opportunities inherent in existing statutory authorities to support land management and conservation efforts such as Environmental Areas designated under Part 323. Furthermore, Environmental Areas could be used to provide flexible buffers in response to changes in water levels. It would be beneficial to do a comprehensive review and evaluate the various tools that might be available in existing statutes and regulations to support protection of coastal wetlands in anticipation of lake level changes.

Recommendation – Identify financial incentives that will encourage waterfront and riparian landowners to protect and retain coastal wetlands

Recommendation – Engage state and local governments in responding to lake level decline through adaptation actions that support shoreline and wetland restoration and protection using techniques that support habitat health. Identify adaptation measures and strategies for addressing these impacts that are appropriate for Michigan’s coastal wetlands, and suited to Michigan’s state and local wetland protection and management framework.

Recommendation – Support identification and installation of shoreline practices that protect, restore and enhance coastal wetlands. Encourage integration of climate adaptation considerations in the Michigan Natural Shoreline Partnership.

Recommendation – Incorporate appropriate preservation, restoration, and similar climate change adaptation measures for coastal wetlands into the state’s Climate Change Action Plan, Wetlands Action Plan, Wildlife Action Plan, and CELCP plan.

Recommendation – Give continuing education credit to local governments for getting training in climate change adaptation such as NOAA’s Climate Ready Great Lakes Training Modules http://www.regions.noaa.gov/great-lakes/?page_id=395

Recommendation – In cooperation with the Michigan Natural Shoreline Partnership, continue to educate the public about the consequences of “hard” shoreline protection techniques and the benefits of habitat friendly practices for coastal and inland shoreline wetlands. Add information regarding possible responses to changing water levels.

Inland Wetlands

Recommendation – Review research on carbon sequestration, associated with recently restored temperate wetlands and evaluate the feasibility of restoring wetlands for carbon sequestration. This may include the possibility of developing wetland carbon sequestration banks to offset or mitigate the impacts of climate change. Dr. William Mitsch of the Ohio State University has recently completed research on this topic. <http://researchnews.osu.edu/archive/freshwetlands.htm>

Recommendation – Develop wetland adaptation training and provide continuing education credits for local government officials and others who take the training. This could be done in coordination with the Michigan Natural Shoreline Partnership to promote management of wetlands adjacent to lakes and support lake water quality.

4. Regulation

General

Recommendation – In cooperation with a range of stakeholders, consider revision of current regulatory processes to integrate climate change adaptations into the wetland dredge and fill permitting, enforcement and mitigation decision making processes. This should include the following processes:

- 1) Identifying what if any changes to the alternatives analysis would be appropriate to address climate change
- 2) Evaluating mitigation practices and whether a policy evaluating the appropriateness of in-kind mitigation is needed if climate change alteration of wetlands is found to be occurring
- 3) Determining if additional changes are needed to the dredge and fill permitting program such as requirements for larger buffers to protect wetlands and/or allow for wetland migration and sustainability in a changing climate, and
- 4) Include protection of wetland carbon stores as a requirement in wetland permitting.

Recommendation – Coordinate with EPA in consideration of changes to 404 Program to integrate climate change concerns.

Recommendation – After definition of climate change criteria and appropriate regulatory conditions are identified and integrated into regulatory policies, train staff, wetland consultants and other professionals on how to incorporate climate change measures into wetland regulatory processes including permitting, enforcement, and mitigation.

Recommendation – Integrate wetland protection and restoration into state flood hazard and climate change initiatives including protection of wetland flood storage and conveyance, increased freeboard in state floodplain regulations, prohibition of fills in wetlands located in floodplains, adoption of zero rise standards for floodways and adoption of a no adverse impact standard for floodplain management.

Recommendation – Prepare and distribute to local and county government a wetland and climate change best management handbook. The handbook should be available online as well.

Coastal Great Lakes Wetlands

Recommendation – Identify climate change adaptation measures for coastal wetlands and encourage coastal communities to incorporate these measures into local plans and ordinances.

Consider potential changes to model ordinances that take climate change and adaptation measures into consideration. Filling the Gaps: Environmental Protection Options for Local Governments 2nd Edition, 2010 http://www.michigan.gov/deq/0,4561,7-135-3313_3677_3696-73358--,00.html could be revised to address climate change. For example, it may be desirable to provide wider buffers adjacent to wetland areas, or to investigate “rolling easements” that can be adjusted to future long term changes in water elevation. http://www.michigan.gov/deq/0,4561,7-135-3313_3677_3696-73358--,00.html

Recommendation – Consider need for climate change adaptation in the Great Lakes Submerged Lands Program; provide options to adapt to uncertain future water levels.

Recommendation – Build upon current interest/concerns with wind energy development (off shore turbines) to encourage considerations of other climate change needs, e.g. protection of coastal habitat during a period of change.

Inland Wetlands

Recommendation – Identify climate change adaptation measures for inland wetlands and encourage communities to incorporate these measures into local plans and ordinances. Consider whether changes might be needed in existing model ordinances and local wetland management materials to address climate adaptation needs. This could be accomplished in part by revising ‘Protecting Michigan’s Wetlands: A Guide for Local Governments’. http://www.michigan.gov/documents/deq/Wetland_eBookFINAL_339529_7.pdf

5. Integration with Other Water Programs for Watershed Management

Climate change will have far ranging impacts on Michigan’s natural resources that are well beyond the scope of this white paper. However, adaptation may, in many instances, involve wetland protection and management. To that extent, wetland climate change adaptation approaches should involve working with other water program areas at a watershed/ecosystem scale. (Coordination with habitat programs is addressed primarily under recommendations for habitat preservation and restoration.)

General

Recommendation – Identify ways to encourage wetlands restoration and conservation as part of establishing green infrastructure. The role of wetlands in climate change adaptation should ultimately be advanced in the Nonpoint source program, in development of TMDLs, in Great Lakes Areas of Concern (AOCs), and in related Great Lakes Restoration Initiative actions.

Technical materials supporting management of wetlands for climate change adaptation should be added to the Michigan Surface Water Low Impact Development (LID) Manual.

Recommendation – Climate changes predicted for Michigan include larger storm events in the winter and spring months when vegetation is largely absent and unavailable to filter pollutants out of runoff. Identify practices that leverage wetland restoration, protection and creation to reduce nonpoint source pollution with a special emphasis on winter and early spring events.

Explore opportunities to manage stormwater to support wetlands conservation and prevent wetland degradation. Climate change is expected to produce larger storm events which will tax existing stormwater infrastructure which is generally planned in anticipation of the ‘average’ 10-15 year storm event. Greater emphasis on infiltration, natural storage and buffer and riparian habitat can support wetland conservation while improving the capacity of communities to reduce pollution and flooding from larger and more frequent storm events.

Recommendation – Provide greater incentives for adopting strategies that provide multiple benefits over single purpose projects. For examples protecting natural floodplains can reduce impacts from floods on nearby and downstream communities, provide wildlife habitat and improve water quality. Low Impact Development can reduce stormwater pollution to local streams, recharge groundwater and reduce annual maintenance costs. In the past various cost/benefit analyses have only considered single purpose outcomes. This is because many federal programs have narrow statutory goals and funding authorities. However, state and local cost benefit analyses can consider a broader range of benefits. This is particularly important in the context of supporting resilient communities and the state should support implementation of these more holistic solutions through benefit/cost analyses that evaluate broader range of costs and benefits.

Recommendation – Provide guidance on how to include wetlands in the comprehensive local government action plans identified in the Michigan Climate Change Action Plan.

Recommendation – the Michigan Climate Change Plan includes a goal to, “Enhance and Encourage economic growth and job creation opportunities through climate change mitigation.” A recent report by Restore Our Estuaries (September 2011) showed that investment in coastal habitat restoration produced jobs at a higher rate than many other sectors.

(http://www.estuaries.org/images/81103-RAE_17_FINAL_web.pdf) Job creation opportunities that are part of wetland restoration, protection and conservation should be documented and included as part the Michigan Climate Change Plan.

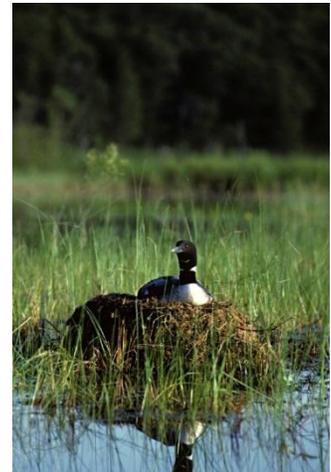
Coastal Great Lakes Wetlands

Recommendation – Identify adaptation actions that will maintain or expand overall biodiversity, increase connectivity of coastal wetland areas, and improve water management to address multiple natural resource goals are priorities.

Inland Wetlands

Recommendation – Work with Nonpoint Source Program to incorporate issues related to wetlands and climate change adaptation into criteria for new or updated watershed plans, as well as proposed implementation funding and definition of priority restoration areas. Encourage protection and restoration of wetlands that will serve multiple functions, including water storage, buffering runoff from anticipated larger storm events, and provision of migratory corridors for wildlife.

Recommendation – Explore the role of wetland protection and restoration in addressing issues in Areas of Concern, including water quality improvement, water management, and removal of biological impairments. Multiple agencies have worked diligently in AOC watersheds to remove impairments; without adequate consideration of potential climate change impacts, many of those advances could be negated. Extra attention to long term runoff control and water management – including the strategic use of wetland protection and restoration – will help to adapt to climate change in these watersheds.



Appendix A

Climate Change Adaptation Management Measures and Wetland Ecosystem Services Matrix

Adaptation to climate change is unlikely to result from the development of entirely new programs, but rather will result from incorporation of climate change considerations into existing management measures. Fortunately, many individual actions that are priorities for wetland managers, town planners and many others – such as protection of habitat, erosion control, protecting water quality, encouraging biodiversity, and providing buffers against natural hazards such as storms and floods – are also actions that will assist in adapting to changing patterns of temperature and precipitation. Increased understanding of these interactions will increase our ability to adapt. Moreover, multiple ecosystem services are potentially benefited by these actions.

While a great deal of uncertainty remains about the scope and rate of climate change, “no regrets” actions are those that will have benefits for the public regardless of the extent of climate change. For example, restoration of wetlands in key watershed locations can benefit water quality and improve fish and wildlife habitat, but may also help to moderate the impacts of more intense storms resulting from climate change, and maintain base flow during dry periods. Likewise, consideration of climate change impacts will encourage “no regrets” decision making by avoiding projects that may be undone by climate change – such as providing compensatory mitigation in an area that may not support wetlands under future hydrologic conditions.

This matrix provides examples of how various wetland management measures recommended as part of a climate change strategy can support the management of multiple wetland ecosystems services. Conversely, those who are responsible for particular wetlands services, such as fish habitat or protection of water quality, may consider how various management measures can also support adaptation to climate change for both wetlands and the general public. The recommendations included in this report reflect specific actions that may be taken to encourage the integrated, no-regrets approach. A cross-section of those recommendations is highlighted in this matrix.

Appendix A

WETLAND MANAGEMENT MEASURES SUPPORTING CLIMATE CHANGE ADAPTATION						
ECOSYSTEM SERVICES	Inclusion of Wetlands in Conservation/Watershed Planning	Wetland Monitoring, Assessment, and Mapping	Wetland Preservation and Stewardship	Wetland Restoration	Wetland Regulation	Outreach and Education
Fish Habitat	Target at-risk aquatic habitat in CELC Plans and other coastal management plans.	Identify gains and losses of wetland habitat over time.	Maintain fish habitat with management measures to protect wetlands at risk from climate change impacts (e.g. hydrologic management). Protection littoral habitat as needed with conservation easements or similar measures.	Restore wetlands to provide littoral and coastal habitat as Great Lakes surface elevations change.	Protect at risk shoreline habitat. Facilitate habitat restoration projects.	Provide information to policy makers, wetland managers, and the public regarding the role of wetlands in climate change adaptation. Provide technical information to wetland managers and conservation agencies to improve sustainability of restoration and preservation project.
Terrestrial Habitat	Incorporate adaptation measures into Wildlife Action Plans, statewide biodiversity plans, and other wildlife management plans.	Identify/map critical and at risk habitat. Evaluate success of habitat management measures.	Protect habitat for at risk species and maintain migratory corridors. Manage to control increased invasive species in changing habitats.	Increase connectivity of wildlife corridors. Expand habitat for at risk species.	Consider climate change impacts in evaluating dredge and fill projects. Facilitate restoration projects. Consider sustainability for mitigation sites under future conditions.	Provide cross training for conservation organizations and water managers to support a coordinated response to changes in hydrologic patterns.
Water Management - Flood Storage and Groundwater Recharge	Identify need for water storage and potential locations for additional wetland storage.	Identify locations for additional flood storage on a watershed scale. Evaluate changes in base flow, and water withdrawal needs.	Respond to changing lake elevations with measure to protect the riparian buffer zone and protect altered littoral zone.	Provide additional flood storage/groundwater recharge. Maintain stream baseflow.	Consider water management functions in evaluation of dredge and fill permits.	
Water Quality Protection	Incorporate wetland management in TMDLs, nonpoint source plans, AOC plans	Identify wetlands that provide protection for at risk waters on a landscape scale, using functional assessment methods.	Maintain wetlands that protect waters susceptible to degradation from increased runoff.	Increase the extent of wetlands to provide filtration of increased runoff.		
Erosion control; storm protection	Use wetland BMPs to control erosion resulting from stronger storms.		Maintain existing coastal and inland lakes shoreline wetlands to provide protection from erosion with increased storm intensity.	Expand shoreline wetlands to protect shorelines from increased storm intensity, replacing wetlands that are lost as water elevations are altered.	Encourage use of green infrastructure in soil erosion and sedimentation control regulations.	
Carbon Sequestration and Climate Change Mitigation		Define metrics to evaluate impacts of climate change. Identify potential areas for increased C sequestration in wetlands.	Consider carbon sequestration capacity in defining wetland preservation priorities (e.g. peatlands)	Consider potential for carbon sequestration in definition of wetland restoration priorities		