Great Lakes Restoration and Climate Change

The Johnson Foundation at Wingspread
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The Johnson Foundation at Wingspread

TABLE OF CONTENTS

OVERVIEW

The waters of the Great Lakes are vast, vital, and abundant, yet they are vulnerable to environmental stress and consumption patterns, both of which are expected to be exacerbated by climate change. Restoration and management efforts, funded in part by the $1.3 billion federal investment in the Great Lakes Restoration Initiative (GLRI), address environmental stressors that threaten the health of the Great Lakes ecosystem. While many of these efforts are making progress toward their restoration goals, new important information and reports on the impacts of climate change have recently been released and consideration of these impacts should be more fully integrated into restoration efforts going forward.

The Great Lakes Restoration and Climate Change event addressed this issue in two ways. The first was to identify the range of science-based climate change impacts on restoration and management within several important focus areas, including nonpoint source pollution, nearshore health, toxic substances, invasive species, wildlife habitat protection and restoration, agriculture water use, and energy water use. The second was to develop recommendations and policy-based strategies to integrate climate change impacts into future restoration projects in these focus areas.

The event brought together local and nationally renowned experts on the Great Lakes, ecosystem dynamics, and climate change. It addressed the most critical challenges facing our binational region as the stewards responsible for managing our finite freshwater resources. The first half of the event was committed to focus groups that produced clear and accurate information on the spectrum of climate change impacts predicted for each focus area, which will be useful to a broad set of stakeholders and project managers. During the second half of the event, focus groups developed a range of policy-based strategies and recommendations to incorporate the predicted climate impacts into measurable and achievable actions for Great Lakes restoration projects. Plenary addresses from leading authorities on Great Lakes climate change were interspersed throughout the event to provide perspective and insight to the ongoing conversation.

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KEY EVENT RECOMMENDATIONS

Build Awareness and Understanding of Climate Change Impacts - Educate stakeholders on the vulnerabilities of the energy cycle to climate change through creative and aggressive energy conservation and efficiency programs. Stakeholders and communities should also be provided with a transparent energy decision-making process that clearly identifies energy sources and the climate impacts of energy decisions.

Develop Comprehensive and Integrated Energy Policies - The U.S. and Canada must develop comprehensive and integrated energy policies at all levels that move away from primary reliance on fossil fuels to a diverse portfolio of sustainable energy sources. In addition, comprehensive energy policy should produce strategies for mitigation, adaptation, and resilience that address all parts of the energy life cycle and scrutinize energy sources with a cost-benefit analysis that includes liabilities and externalities.

Maximize Pollution Reductions - Reduce nutrient runoff, toxic substance discharges, and wastewater overflows to zero, as per the US Clean Water Act. In addition, require that all new wastewater treatment and containment infrastructure integrate 100-year climate change predictions into their capacity estimates and enforce firm penalties for non-compliance to discharge regulations.

Develop Mechanisms to Promote Interagency Collaboration - Revisit and revise rules preventing federal matching funds for large-scale interagency restoration efforts. Alternatively, federal agencies should make increased use of agency-aligned nonprofit groups for collaborative efforts and structure large-scale restoration projects into discrete units that promote strategic interagency coordination but allow for agency autonomy within each unit.

Align Farm Bill Incentives with Wise Water Use - Align Farm Bill subsidy incentives with local hydrological water quality and quantity realities under pressure by climate change. Incentivize farmers to select crops best suited to their land and integrate the most efficient means of irrigating and fertilizing their land.

Account for Virtual Water - We currently lack a comprehensive understanding of the amount of water that goes into all agricultural products leaving the Great Lakes basin. Calculating this "virtual water" export can inform intelligent policies to optimize land-use and water-use, motivating water-wise crop selection and water-efficient agricultural practices.

Create Updated Study on Climate Change Impacts - While the projected trends in climate change are largely known, a detailed update on the state of knowledge should be published and made accessible to the public. Recommended topics of study include lake levels, invasive species, water temperatures, changing vectors of wind patterns, critical lands and habitat inventory and analysis, species scenarios, human adaptation needs, ecosystem needs, and identification of critical species important to ecosystem health.

Develop Upstream Solutions - Restoration projects should focus on upstream, land management-based solutions. Land-management projects focused on reduction of phosphorus in runoff and phosphorus re-suspension, improved stormwater management, and green infrastructure projects that slow discharge of nutrients and sediments are important for successful integration of climate change into the restoration projects.

Provide Firm and Fair Enforcement of Existing Law - Although enforcement may often be politically unpopular, widespread and consistent enforcement of reasonable, lawful standards, such as those flowing from the Great Lakes Compact and the Clean Water Act, can motivate optimal land- and water-use behavior. These laws should be enforced in order to incentivize the most efficient and environmentally beneficial use of water resources.

PLENARY ADDRESSES

"Canary in the Coal Mine: Climate Science in the Great Lakes"

Dr. Paul Roebber, Distinguished Professor and Associate Dean, University of Wisconsin-Milwaukee School of Freshwater Sciences and Department of Mathematics

Climate change has already affected Great Lakes in a variety of ways. An air temperature increase of just 1° F since 1980 has driven summertime surface water temperatures 8° F higher and has resulted in greatly increased evaporation losses. Water temperature increases mean less ice cover, and less ice allows more solar energy to contribute to evaporation instead of melting. Cumulatively, Lake Michigan has lost five feet of water level over this period, and similar effects are occurring on all large inland lakes. Lower lake levels reduce ships' cargo capacity and necessitate costly dredging, and also affect access for recreational boating and fishing activities, as well as the economies dependent on marinas and piers. And while lake levels have always fluctuated due to climate, the variability over the last 15 years is occurring around a lower mean. Future lake level variability is projected to range from +5 feet to -10 feet. Furthermore, Milwaukee has experienced five 100-year or greater storm events since 1999, and while we have seen precipitation increases in the Great Lakes region, downscaled climate models cannot resolve "flashy" events such as thunderstorms, adding regional unpredictability to the overall greater variability of precipitation, making climate change adaptation both much more difficult and even more essential.

Despite locally frigid temperatures, winter 2013-14 was actually the eighth warmest winter on record in the Northern Hemisphere. In fact, over the past 29 years, every month has been above the historical global temperature average. Since 1990, carbon dioxide (CO_2) levels have increased 44 percent globally. Because of the long residence time of CO_2 in the atmosphere, climate change over the next 50 years is already mostly out of our control and effectively cannot be mitigated. However, we can mitigate climate change over longer time horizons, and improved interlake control strategies may allow for much greater adaptation to the inevitable effects of climate change on lake levels combined with greater variability. Observed climate change effects in the region to date are just the tip of the iceberg. Climate change challenges for the Great Lakes will require interstate and international cooperation and policy responses to address temperature increases and lake level fluctuations through mitigation and robust adaptation strategies.

"Climate Forward: A New Approach to Wisconsin Climate and Energy"

Jane Elder, Director, Wisconsin Academy

Wisconsin is currently dependent on coal for energy production. The state has only one remaining nuclear power plant, and only 10 percent of the state's energy portfolio comes from renewables, half of which originate from out of state. Under current policies, electric rates are likely to become more expensive in the region, yet Iowa's energy rates are lower than rates in

Wisconsin due to their adoption of wind energy production. Such use of renewable energy sources could empower Wisconsin to become a more energy-independent state.

Wisconsin should strive for a 1-1.5 percent increase in annual renewable energy generation by incorporation of solar energy, smart biomass energy production, and wind energy. With a long legacy of conservation and a Midwestern work ethic, Wisconsin has the social values needed to implement this change. Furthermore, the technology already exists to modernize Wisconsin's energy policies toward sustainability, as seen in other Midwestern states. Wisconsin needs to move to a 21st-century business model that incorporates whole-system thinking, integrating climate change and human health into state energy policies.

"Taking Charge to Take Care: 'Proaction' for the Great Lakes Region"

Cameron Davis, Senior Advisor to the U.S. Environmental Protection Agency Administrator

As an economic hub and a place of "spiritual renewal," the Great Lakes ecosystem is critical to the entire nation. Currently, the EPA and 10 other federal departments are working to protect, restore, and maintain this vital resource, including work to incorporate climate change resilience.

Climate change is anticipated to impact the Great Lakes ecosystem in numerous ways, including increased variability in temperatures and precipitation, drops in dissolved oxygen, more extensive harmful algal blooms, exacerbated flooding, increased nonpoint source pollution, and more combined sewer overflows.

In response to these climate change impacts, several federal policy tools have been developed to elicit "proaction," or action that initiates change rather than reacts to it. On the binational level, Annex 9 to the U.S.-Canadian Great Lakes Water Quality Agreement of 2012 includes for the first time an "annex," or issue-specific provision, on climate change. It commits the federal governments of both countries to consider climate change impacts throughout the Agreement. On the national level, the President's 2013 Climate Action Plan charges the EPA to work with states to create carbon pollution standards and integrate climate change impacts into its projects. In addition, all federal agencies have developed climate change adaptation plans. At the regional level, the 2015-2019 GLRI Action Plan will increase the resilience of the Great Lakes ecosystem by supporting work to integrate climate adaptation into key funding decisions based in part on recommendations by the Government Accountability Office, Great Lakes Advisory Board, and other Great Lakes stakeholders. Overall, the current administration will continue its commitment to protecting the Great Lakes from the effects of climate change through binational, national, and regional efforts.

"Future of Great Lakes Water-Energy Nexus"

Maude Barlow, National Chairperson, Council of Canadians

New sources of "extreme" energy, such as tar sands oil and shale gas, are being aggressively extracted in North America, and the methods used to extract and transport these energy sources are more water and energy intensive than traditional ones. Alberta tar sands are producing enough bitumen to exceed domestic market capacity, with production rates expected to reach 5 million barrels of heavy crude oil per day, yet transporting bitumen requires 3-5 times as much water as conventional oil, placing major strains on water resources. Extraction of shale gas in the U.S. has also escalated in recent years, with more than 82,000 fracking wells permitted since 2005, but to develop all the shale gas reserves in just four Great Lakes states, more than 37 billion gallons of water per year would be needed.

The web of pipelines, refineries, and oil shipments tied to extreme energy is turning the Great Lakes into a carbon corridor. The U.S. has 66 bitumen refineries that process tar sand oil, and the majority of those are in Great Lakes states. Over 18,000 miles of new crude pipelines are planned in the U.S., much of which will go through the Great Lakes region. Expansions to existing pipelines, such as the "Alberta Clipper" that terminates in Superior, Wisconsin and the twin underwater pipelines that run under the Straits of Mackinac, are being planned to accommodate increased tar sand oil. In addition, proposals to transport bitumen and fracking waste across the Great Lakes are also being considered, despite a lack of clean-up protocols in the event of a spill.

The unchecked expansion of extreme energy threatens the quantity and quality of water in the Great Lakes, but communities and policymakers can take steps to protect this resource. Aggressive North American energy policy must be adopted that shifts from reliance on fossil fuels to sustainable energy sources. Such a policy would decrease the demand for tar sands oil and shale gas. A moratorium on further extreme energy extraction would allow time to perform adequate risk assessment and quantify impacts. A transparent energy decision-making process that includes all competing interests would promote the public trust and prevent energy and pipeline companies from dominating the conversation. Precedents for failure, such as disappearing rivers in China and the diminishing Ogallala Aquifer, should provide ample motivation to take action before it is too late

FOCUS GROUP REPORTS

FOCUS GROUP 1: NONPOINT SOURCE POLLUTION, NEARSHORE HEALTH, AND TOXIC SUBSTANCES

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Summary

Climate change is already evident in the Great Lakes, and its impacts on nonpoint source pollution, nearshore health, and toxic substances will continue to grow in the coming decades. To adapt to these impacts, policymakers must promote nutrient management on a watershed basis, enforce zero discharge rates of pollutants, plan the management of newly exposed coastal habitat, regularly inventory Area of Concern beneficial use impairments, diversify and expand the Great Lakes Interagency Task Force, and develop ways to promote federal interagency collaboration. Understanding the nature and extent of climate change impacts will also be key to setting investment priorities. Furthermore, effective communication of the perils of climate change to the public will be vital in securing the necessary funds to implement these adaptation strategies.

Climate Change Impacts on Nonpoint Source Pollution, Nearshore Health, and Toxic Substances

Climate change will likely impact the management of nonpoint source pollution, nearshore health, and toxic substances in the Great Lakes basin. More frequent and intense rain events are predicted to increase coastal erosion, increase nutrient and sediment runoff, overwhelm existing wastewater containment and treatment infrastructure, and undermine efforts to contain toxic sediments. Higher temperatures may strengthen lake stratification, and in conjunction with increased nutrient loading, promote the frequency and extent of harmful nearshore algal blooms. Lower, more variable lake levels may reduce shipping and port capacity, and subsequent channel dredging may resuspend toxic sediments. Lower lake levels may also drain existing coastal wetlands, while at the same time exposing new habitats at the receding land-water interface.

Uncertainty regarding the probability and extent of these climate change impacts is a major policy challenge. Developing regulations, infrastructure, and management plans that effectively encompass all possible climate change scenarios is a tremendously expensive and labor-intensive endeavor and is not realistic in the current funding environment. Furthermore, there are climate change impacts that cannot be predicted. The immense complexity of system interactions triggered by climate change may result in impacts that will remain unforeseen until they occur. Despite these uncertainties and fiscal limitations, current and future climate change impacts must be taken into account when managing nonpoint source pollution, nearshore health, and toxic substances in the Great Lakes basin.

Recommendations for Integrating Climate Change into Future Restoration Projects

Look Upstream - Localized efforts to address Great Lakes chemical loading will likely be overwhelmed by increased runoff from upstream agriculture. Great Lakes restoration projects addressing nonpoint source pollution must manage nutrients at the watershed level in order to be effective. This will require collaboration between farmers, non-government organizations, publicly owned treatment works, federal agencies, and other stakeholders. Great Lakes policymakers should emulate existing decision-making models that bring these parties to the same table, such as that being proposed in the USDA Regional Conservation Partnership Program written into the Farm Bill.

Reduce Pollution Discharge to Zero - To fully address nonpoint source pollution and nearshore health issues resulting from increased stormwater runoff, discharge of nutrients, toxic substances, and wastewater from all sources must be reduced to zero. In addition to watershed nutrient management, this will require that new wastewater treatment and containment infrastructure integrates 100-year climate change predictions into their capacity estimates. Furthermore, penalties for not adhering to zero discharge regulations must be punitive enough to convince stakeholders that compliance is cost-effective.

Nearshore Zone Management - The recession of nearshore waters due to lower lake levels may expose a unique habitat along the coasts of the Great Lakes that should be managed to promote climate change adaptation. This strip of land, or "Sapphire Necklace," could be planted with vegetation that would intercept stormwater runoff and filter out nutrients and pathogens that would otherwise reach the Great Lakes. Toxic substances, such as heavy metals, could be drawn from newly exposed sediments by employing techniques such as phytoremediation. Human development along shorelines would also benefit from having an extra buffer of protection against increased wave action from intense storm events. By regulating the development of this newly exposed habitat and investing in its management, Great Lakes policymakers could use one climate change impact to mitigate others.

Regular Inventory of Area of Concern Beneficial Use Impairments - Great Lakes Areas of Concern (AOCs) are designated locations that have experienced beneficial use impairments (BUIs) due to environmental degradation. To be delisted, an AOC must meet and maintain certain criteria that demonstrate all BUIs have been removed. Many BUIs, such as beach closings and algal blooms, are sensitive to climate change, and the list of BUIs within an AOC may grow and change over time. Subsequently, AOCs should take regular inventories of BUIs to account for the impacts of climate change. Such a step would lend more credibility to a delisting status. Furthermore, once an AOC is delisted, monitoring should continue indefinitely to identify new or re-emerging BUIs that may arise over time.

Expand GLRI Decision-making Structure - The Great Lakes Interagency Task Force (GLITF), representing 11 federal agencies, is the primary coordinating entity for GLRI projects. While the GLRI Action Plan was developed with input from the Great Lakes Advisory Board, a non-federal group representing a broad range of interests, the GLITF has final authorization on individual project funding. The all-federal GLITF should be expanded and diversified with non-federal expertise and stakeholders to ensure a wider set of restoration interests are represented by funded projects. This will also promote strategic coordination with existing non-federal Great Lakes restoration projects and increase the exposure of GLRI funding opportunities to more stakeholders.

Develop Mechanisms to Promote Interagency Collaboration - Adapting to climate change in the Great Lakes basin is an enormous effort that requires collaboration. Unfortunately, current rules do not allow federal matching funds for large-scale federal interagency efforts. These rules should be revisited and revised to allow agencies of varying expertise to work together on collaborative restoration projects, rather than develop piecemeal efforts that risk redundancy and wasted resources. Alternatively, federal agencies should use agency-aligned nonprofit partners, such as the National Fish and Wildlife Foundation, to work around existing restrictions and channel resources into projects with other federal agencies without requiring a direct partnership. Furthermore, large-scale restoration projects could be "shared" by structuring them in such a way that different agencies can take charge of discrete units without having to coordinate beyond initial assignments of responsibility.

Key Messages

1.) Failure to adapt restoration projects to climate change impacts will likely lead to failure of the projects and the investments.

2.) Understanding the nature and extent of climate change impacts will be crucial to setting adaptation investment priorities.

3.) Effectively communicating the perils of climate change to the public will be vital to securing and sustaining the funds needed to implement adaptation strategies.

FOCUS GROUP 2: INVASIVE SPECIES AND HABITAT AND WILDLIFE PROTECTION AND RESTORATION

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Summary

A healthy ecosystem benefits the extensive coastlines, numerous wetlands, connecting greenways, and regional watersheds of the Great Lakes basin by providing habitat essential to support and sustain native wildlife. Great Lakes terrestrial and aquatic habitats face many threats. Development, altered flow regimes caused by dams and other control structures, and the introduction of toxic substances and excess nutrients all contribute to the degradation of functional ecosystems. More than 180 invasive species are outcompeting native species in many areas of the Great Lakes basin. Great Lakes habitats face other climate change impacts, such as increased water temperatures, decreased annual ice cover, decreased lake levels, altered precipitation patterns, and increased air temperature. Climate change will also increase the threat posed by invasive species in the Great Lakes region. To adequately address these issues, the current state of knowledge on Great Lakes climate change must be updated. Furthermore, and a Great Lakes Climate Change Collaboration Forum, similar to that utilized

during the establishment of the GLRI, should be formed to bring climate change to the forefront of current policy.

Climate Change Impacts on Habitat and Wildlife Protection and Restoration, and Invasive Species

The current and future impacts of climate change on Great Lakes habitat are numerous. Climate-induced shifts in wind vectors over the Great Lakes affect lake stratification, nutrient transport, and acidification. Changes in any of these parameters can greatly alter the chemical and thermal regimes of lake habitats, placing stress on native plant and wildlife species and creating opportunities for invasive species to establish. Climate change may also impact delicate cold-water streams that are critical to the maintenance of sustainable fish populations in Wisconsin. Warmer groundwater inputs and air temperatures may raise stream temperatures above critical thresholds that put fish at increased risk for predation, parasites, and disease.

Recommendations for Integrating Climate Change Into Future Restoration Projects

Create Updated Study on Climate Change Impacts - While the projected trends in climate change are largely known, a detailed update on the state of knowledge should be published and made accessible to the public. Recommended topics of study include lake levels, invasive species, water temperatures, changing vectors of wind patterns, critical lands and habitat inventory and analysis, species scenarios, human adaptation needs, ecosystem needs, and identification of critical species important to ecosystem health. This study should include the entire Great Lakes watershed region (including groundwater-shed and air-shed) and be completed by the International Joint Commission within a timeline of 18 months from the request. Additional actors may include the Great Lakes Science Advisory Board and the Great Lakes Water Quality Board. This summary document would form the basis for analysis of resilient habitat in the Great Lakes region and provide a framework for management strategies of keystone species.

Develop Upstream Solutions - The groundwater-shed of the Great Lakes should be utilized as the boundary of the system as the lakes are receiving bodies for groundwater and surface water. The GLRI should include projects focused on upstream, land management-based solutions. Land-management projects focused on reduction of phosphorus in runoff and phosphorus re-suspension, improved stormwater management, and green infrastructure projects that slow discharge of nutrients and sediments are important for successful integration of climate change into restoration projects. Investment in natural and historical wetland restoration over creation of new wetlands is critical to maximize carbon sequestration potential and resilience to climate change. The integration of connectivity greenbelts for migrating species between natural habitats is important for sustaining native species populations. Finally,

the group recommends establishing community monitoring "SWAT teams" for early detection and prevention of establishment of invasive species in Great Lakes habitats.

Develop Lake-Based Adaptation and Coping Policies - Due to large variability between lakes, different policy responses are necessary for each lake. Adaptation projects need to effectively deal with this variability and be robust. However, adaptation will not be adequate to counter environmental costs. While the region needs to adapt to attempt to minimize losses, realistically, the region needs to develop coping mechanisms to live with the habitat losses we are already experiencing.

Integrate Prevention Measures - Overall, the integration of prevention and protection measures into the GLRI will provide the greatest benefits to the Great Lakes region and the greatest returns on resources invested. GLRI funded projects that focus on prevention of invasive species establishment and protection of critical habitats will provide the greatest resiliency to climate change.

Promote Cross-Category Projects - Currently, the success of GLRI funded projects is determined based on accomplishment of goals within the category to which the project is assigned. Breaking down these silos of scoring and reporting mechanisms for GLRI funded projects is necessary to value cross-category projects. This will improve inclusion of climate change into habitat-focused projects and invasive species projects, without compromising the original intention of the project goals.

Adopt Scoring Criteria for Integration of Climate Change into GLRI - Climate change impacts should be included in future GLRI funded projects. Developing criteria for scoring points of climate resilience into GLRI funded projects is necessary to ensure success of the GLRI.

Key Messages

1.) Prevention is key. Integrate prevention and protection measures for climate change resilience into mechanisms such as the GLRI. Development of such measures will be difficult, however, and requires further discussion.

2.) Four pillars of adaptation include the anticipation of climate change impacts, prevention of negative impacts on critical habitats when possible, conservation of critical habitats, and restoration of critical habitats when necessary.

3.) Where adaptation and mitigation fails, coping is all that we are left with. Coping should not be seen as a sufficient alternative, but rather as a realistic means to deal with impacts the Great Lakes region has already experienced.

4.) The creation of a Great Lakes Climate Change Collaboration Forum would be beneficial for the region to address climate change through a process similar to that utilized during the development of the Great Lakes Compact.

FOCUS GROUP 3: AGRICULTURE PRODUCTION AND CONSUMPTION IN THE GREAT LAKES BASIN

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Summary

Climate change is expected to lengthen the growing season in the Great Lakes region, resulting in the potential for increased agricultural capacity and concomitant increase in water demand and nutrient use. Climate change is also expected to lead to longer drier periods, increasing demand for irrigation, and flashier intense precipitation, increasing risk for nutrient and sediment loading into waterways. Seasonal changes to precipitation, snowmelt, and evapotranspiration will also add uncertainty to groundwater recharge rates, which can impact available groundwater supply. Global climate change is also expected to play a key role in modifying global demand for Great Lakes agricultural exports, which directly influences in-basin land use and therefore water quality. To adapt to these impacts, policymakers must get agricultural producers to the table to develop and implement strategies to optimize land use based on local hydrology, incorporate wise water- and land-use incentives into the U.S. Farm Bill, adopt measurable numerical standards for water quality at the subwatershed scale, and have the courage to enforce existing law. We can't make the breadbasket bigger at the expense of the Great Lakes.

Climate Change Impacts on Agricultural Production and Consumption in the Great Lakes Basin

An extended growing season, amplified variation in crop range and selection, increased intensity of agricultural production, drier soil conditions, greater demand for water and nutrients, uncertain groundwater recharge changes, more frequent and intense storms, shifting regimes of crop pests and pesticide use, and uncertain change in global demand for agricultural exports are all expected impacts to the Great Lakes basin due to climate change. Anticipating these impacts underscores the urgency to craft an adaptive agricultural policy that values not only bushels per price but also explicitly values water quality and quantity in order to ensure both long-term productivity and environmental health.

Recommendations for Integrating Climate Change into Future Restoration Projects

Bring Agricultural Producers to the Table - Great Lakes policymakers must successfully engage agricultural producers in developing and implementing agricultural policy strategies together. Policies without farmer buy-in are less likely to prove effective and instead risk being derided as regulatory attacks on a way of life. Many farmers perceive their role as feeding the world, a noble mission that should be deemed inconsistent with degrading local environmental quality. With climate change impacting the means for farmers to fulfill their mission, proactive changes in the policy arena designed to increase the resiliency and/or productivity of farmers, while bolstering the quality of the Great Lakes basin, can be construed as win-win strategies with the chance for broad-spectrum buy-in. Social science research should be implemented to encourage and measure such multi-scale collaboration and ensure that groups on the ground are empowered to steward future changes to land and water use.

Align Farm Bill Incentives with Wise Water Use - The U.S. Farm Bill is a key driver of agricultural behavior in the Great Lakes basin due to the various and complex incentive structures it provides for farmers. Aligning Farm Bill subsidy incentives with local hydrological water quality and quantity realities under pressure by climate change is a policy change that can benefit both the region's environment and farmers, but such action promises to be difficult because it challenges the status quo. Optimal crops for a region's hydrology may not be the crops historically planted in that region or those currently subsidized by the Farm Bill; therefore, policymakers must collectively help farmers select crops best suited to their land, incentivize the most efficient means of irrigating and fertilizing that land, and leverage or modify existing subsidies to influence behavior.

Optimize Land Use Based on Local Hydrology - Field assessments of water quantity and quality at the subwatershed scale, including aquifers, should form the basis for determining reasonable allocations of available supply to agricultural and other uses as well as permissible land-use practices and nonpoint-source agricultural discharges. The goal is to respect the natural limits of groundwater and surface water resources in the face of climate change and other system demands/impacts. In recognizing groundwater resources as finite, Great Lakes policymakers should seek to emulate the State of Michigan, which in its permitting seeks to guarantee all legitimate groundwater users adequate access to fulfill their needs at the same time protecting

the environment against adverse impacts due to unreasonable withdrawals. They should not emulate the State of Wisconsin, which recently legislated policy that removes the state's ability to consider cumulative impacts of high-capacity wells on lakes and streams.

Adopt Measurable Numerical Standards for Water Quality at the Subwatershed Scale - Flowing from a Total Maximum Daily Load (TMDL) approach to watershed management, subwatershed-scale standards for water quality that do not target specific farmers but rather involve all watershed stakeholders and dischargers working toward a scientifically relevant shared water quality target should be encouraged. Tying water quality targets to numerical standards allows for the measurement of progress toward shared water quality goals, for example levels of phosphorus and nitrogen that do not impair aquatic life.

Account for Virtual Water - Understanding and communicating the calculus of "virtual water" exported from the Great Lakes region in agricultural products is a step toward conserving in-basin water that is expected to become a scarcer resource under climate change. We currently lack a comprehensive understanding of the amount of water that goes into all agricultural products leaving the Great Lakes basin. Calculating this "virtual water" export can inform intelligent policies to optimize land- and water-use, motivating water-wise crop selection and water-efficient agricultural practices.

Predict Future Agricultural Uses to Prepare for Water Quality Impacts - Though the magnitude and direction of such changes is not certain, global demand is likely to continue to drive agricultural commodity prices within the Great Lakes basin. Global climate change is expected to dynamically interact with global demand. It is important that the region's land and water use not purely become a function of global demand. For example, escalating global demand for water-intensive crops might conceivably incentivize the production of such crops in areas of insufficient water supply—even if the increased profit from increased global demand might make the increased irrigation or pumping costs seem palatable to in-basin producers. The best policies should help farmers to profit by growing optimal crops considering available current and future water resources rather than pushing yields artificially high using water essentially borrowed from the future.

Have the Courage to Enforce Existing Law - The Great Lakes-St. Lawrence River Basin Resources Compact is not just about out-of-basin withdraws. The Compact includes provisions to scrutinize large water withdraws within the basin. This scrutiny should be exercised publicly and diligently in order to incentivize the most efficient and environmentally beneficial use of water resources by agriculture. Similarly, the Clean Water Act (CWA) is not just about point industrial discharges. The CWA includes provisions applicable to concentrated animal feeding operations (CAFOs), nonpoint-source agricultural pollution, and nutrient biosolids. These should be enforced in order to incentivize the most efficient and environmentally beneficial use of water resources. Although enforcement may often be politically unpopular, widespread and consistent enforcement of reasonable, lawful standards, such as those flowing from the Compact and CWA, can motivate optimal land- and water-use behavior.

Key Messages

1.) Climate change is poised to increase basin agricultural production capacity, but a condition of enhanced production must be to measurably reduce environmental impacts by living within natural system limits.

2.) As climate change and other factors vary the natural limits of the Great Lakes basin, we must be more diligent about using land and water resources responsibly, incorporating true farming costs into policies and practices to ensure long-term productivity.

3.) Climate change offers policymakers and society the opportunity to positively transform the relationship between the agricultural community and the Great Lakes environment.

FOCUS GROUP 4: ENERGY PRODUCTION AND CONSUMPTION IN THE GREAT LAKES BASIN

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Summary

Climate change will have increasing impacts on energy production, consumption, and transportation in coming decades and must be incorporated into the planning of Great Lakes communities, institutions, and governments at all levels. Decreasing lake levels have already negatively impacted shipping and recreational activities on the Great Lakes. Worthy of equal consideration are the impacts that energy has on the environment. In the face of climate change, the ultimate goal is achieving and maintaining ecosystem integrity and human health.

Climate Change Impacts on Energy Production, Consumption, and Transportation

Current energy production emits significant quantities of greenhouse gases which fuel climate change. Additionally, current methods of energy production require large quantities of water, a resource increasingly stressed by a changing climate. Energy consumption around the Great Lakes is projected to increase to match population and demographic trends. Transporting energy via piping, shipping, rail, and trucking poses threats to the environmental integrity of the Great Lakes. For example, the 60-year-old pipes beneath the Mackinaw Bridge transport 22 million gallons of crude oil under the Great Lakes on a daily basis. According to government sources this pipeline has never cracked; however, since 1990 more than 100 million gallons of mostly petroleum related hazardous chemicals have been released into the Great Lakes. Without doubt, our current and projected production, consumption, and transportation of energy negatively impact our environment.

To meet increasing energy demands, more extreme sources of energy are being explored in the United States and Canada such as hydraulic fracturing operations and the mining of tar sands. Plans exist to use the Great Lakes for barge and tanker transport of fracked oil, fracking wastewater, and nuclear waste. Production and transport of extreme energy in the Great Lakes threaten the region in new and unprecedented ways.

Recommendations for Integrating Climate Change into Future Restoration Projects

Develop Comprehensive and Integrated Energy Policies - The U.S. and Canada must develop comprehensive and integrated energy policies at all levels, from households to the entire Great Lakes region. Such policies should move away from primary reliance on fossil fuels to a diverse portfolio of sustainable energy sources. In addition, new and existing energy sources should be scrutinized with a cost-benefit analysis that includes liabilities and externalities. Comprehensive energy policy must produce strategies for mitigation, adaptation, and resilience and address all parts of the energy life cycle, including production, consumption, transportation, and waste disposal.

Build Awareness and Understanding of Climate Change Impacts - Educate communities on the vulnerabilities of the energy cycle to climate change. Reframe climate change as a reality, rather than a debate. Develop creative learning tools and promote aggressive energy conservation and efficiency programs that allow individuals to take direct action. Provide communities with a transparent decision-making process that clearly identifies the sources of their energy and outlines the climate change impacts of their energy decisions. In addition, create a meaningful forum in which individuals can influence local and regional energy decisions.

Key Messages

1.) Call for courageous, ethical leadership on sustainable energy at all levels.

2.) Develop comprehensive and integrated energy policies at all levels, from U.S. and Canadian governments to local communities, institutions, and households.

3.) Build awareness and public understanding of climate change impacts in all that we are doing.

CONCLUSION

Environmental stressors on the Great Lakes are being exacerbated by climate change. As the frequency and severity of weather patterns shift simultaneously with population growth and increasing consumption, the binational Great Lakes region will require a greater capacity to address water quantity and quality issues that will ultimately impact economic stability and ecosystem health. The purpose of the *Great Lakes Restoration and Climate Change* event was to convene Great Lakes leaders and climate experts to assess the range of impacts of climate change on the Great Lakes and to develop policy-based strategies to integrate climate variation into future restoration and stewardship practices.

The overarching conclusion from the event is that the impacts of climate change are already urgent and consequential in the Great Lakes system. Four focus groups clarified the science-based climate change impacts on energy production and consumption, agricultural production and consumption, pollution, invasive species, nearshore health, and habitat protection in the Great Lakes and concluded that these impacts are jeopardizing restoration efforts, as well as economic investments. Participants developed suggestions for incorporating climate change into measurable and achievable actions for practice and policy, which are now available for other working groups, task forces, stakeholders, and stewards to use in new and existing restoration projects.

The Great Lakes are one of the world's greatest natural assets. According to the EPA, they hold 21 percent of the world's surface freshwater and approximately 84 percent of North America's surface freshwater. The *Great Lakes Restoration and Climate Change* event convened renowned regional and national leaders, experts, and champions of the Great Lakes to address the most critical challenges of climate change to restoration efforts in this vital system. The next step, which emerged out of the recommendations and generated strong momentum, is to build a Great Lakes Climate Task Force with a Great Lakes policy network and a strong emphasis on climate communication. We will support and expand the work of the Great Lakes stakeholders, with an emphasis on the responsible stewardship of our vital freshwater resources.