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Using Future Scenarios to Identify Potential LAMP and Watershed Planning Measures for Climate Change Adaptation along Lake Ontario

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Executive Summary

The drastic changes in nutrient loads and water clarity observed in Lake Ontario over the past two decades illustrate the potential for human behavior to influence this large, important ecosystem. While scientists work to understand how the ecosystem has changed and anticipate future changes, there is a concurrent need to educate a broader stakeholder group about future uncertainties in the ecosystem and the services it provides (Walker et al. 2002). *Scenario Planning* has proven to be a useful tool to help prepare for uncertain futures. Scenarios developed with multi-disciplinary input represent plausible, but alternate, future conditions of a system of interest (Wack 1985). As such, they can provide a means of understanding potential future impacts, such as those related to climate change, and can help develop local, adaptive decision-making to reduce the severity of those impacts (Wack 1985; Peterson et al. 2003). In 2012, New York Sea Grant organized a scenario workshop, funded by the Great Lakes Restoration Initiative (GLRI) as an exercise to explore possible scenarios for the future of the Lake Ontario ecosystem with input from diverse stakeholders (Workshop I). Participants at Workshop I identified precipitation extremes and human demographics as two main drivers of ecosystem trajectories. The group developed four narratives describing these future states and identified the underlying conditions.

The four identified scenarios (future states) were as follows.

1. Drier Climate- Slow Population Growth: "Boatless Lake Ontario"
2. Wet Climate-Slow Population Growth: "Raging Runoff"
3. Drier Climate-Fast Population Growth: "Crowded Beaches"
4. Wet Climate-Fast Population Growth: "Soggy Stripmalls"

With funding from the Great Lakes Integrated Science Assessment program (GLISA), an iterative approach was taken to develop draft recommendations for the binational Lake Ontario Lake-wide Action and Management Plan (LAMP), and for watershed planners to consider when adapting existing (and new) plans to climate change. During the May 2015 workshop (Workshop II), draft recommendations were synthesized from diverse stakeholders that considered long-term extremes in precipitation (extreme precipitation and drought) and human demographic shifts (slow and rapid population growth) as created in Workshop I in September 2012. Follow-up workshops were held in the fall of 2015 (Workshops III-A and B) to gather public input on these draft recommendations. Workshop attendees used their local knowledge, beliefs, and opinions to refine and prioritize potential management and policy actions that would add to the system's resiliency and buffer the impact of future uncertainties. These recommended actions are being shared with local, State, and Federal organizations involved in watershed and lake planning.

Introduction and History

Within the last decade, interest in the impacts of climate change has significantly increased. Concomitantly, there has been widespread recognition that action must be taken to reduce these impacts and adapt to the potential changes. The development of adaptive planning (sector-specific), however, has lagged behind. This can, in part, be attributed to uncertainty and the lack of fine-scale climate impact projections for local and regional levels as most projections are for broader geographic areas (Hayhoe et al. 2008). However, predictive models even at finer scales may never be completely accurate in forecasting future states. Thus, tools to help understand and plan within the context of uncertainty are needed (Wack 1985). The northeastern US, a region predicted to experience both more flooding associated with high frequency rainfalls and more droughts due to warming and longer no-rain periods (Kunkel et al. 2014), is one example highlighting the challenges of planning under predicted high variability.

Many tools are available to assist communities in assessing their vulnerabilities to the impacts of climate in the areas of human health, infrastructure, ecosystems, and emergency response, as well as planning strategies for adapting to the changing climate. Although tools are available, previous surveys and studies make us aware that a gap exists between communities' awareness of the climate and actually taking action toward adaptation. In fact, surveys completed in the Great Lakes region that were targeted at local officials and government staff clearly indicate that a majority of communities in the region are not currently incorporating climate adaptation concepts into their planning processes, despite awareness of current and potential impacts of the changing climate. (Nelson 2011.)

Alternatively, scenario planning has been identified as a useful process that can help organize thinking about uncertain futures. Originally used by militaries and businesses, scenario planning has been increasingly used in socioecological settings such as the Millennium Ecosystem Assessment and the Great Lakes Futures Project (Wack 1985). One important outcome of the process is helping a diverse audience recognize what

different people value about their environment and how their activities could impact those resources. The process is flexible, but generally built from dialogue between multiple stakeholders from diverse backgrounds (e.g. government, scientists, business owners, recreational users, environmental advocates, etc.). The goals of the dialogue are to define the system, area, and resources that are the target of the exercise and to identify the 'drivers', the forces or key influences, that will most likely change the system in the future. Assessing how drivers may unfold in the future, given uncertainties, gives rise to simple, yet striking contrasting futures (Walker et al. 2002; Peterson et al. 2003).

In our exercise, we conditioned the "projected" future states to be realistic and equally plausible. Participants develop alternative, logically consistent stories (not fanciful predictions—but simple "projections") about the system's future based on how the identified uncertainties might unfold. These stories portray both the positive and negative consequences of a future 30-40 years away and include economic, cultural, and ecological elements (Peterson et al. 2002). A real strength of this process is that, because the stories are developed by individuals who are familiar with the system, the stories reflect local experiences, become more believable, and are accepted by the participants. A powerful learning moment occurs when stories are shared and workshop participants recognize how simple but uncertain contrasting incidents can lead to cascading events, resulting in drastically different futures (Peterson et al. 2002). In addition, scenario planning can be used to identify individual or common actions that can be taken today to help prepare for any of the scenarios.

Scenario Development for Lake Ontario

In September 2012, a diverse set of stakeholders met for two days at the Cornell Biological Field Station to utilize the scenario planning process to imagine and create four different future scenarios (30-40 year out) for Lake Ontario and its coastal communities (Workshop I). The workshop involved twenty-four diverse stakeholders representing researchers, marina operators, fishermen, small business owners, angling organizations, county tourism and health departments, sport-fishing promotion, charter boat industry, cooperative extension, State watershed managers, shoreline property owners, county soil and water, non-profit groups, and academics from the United States and Canada (Ontario Ministry of Natural Resources). New York Sea Grant's Recreational Fisheries Specialist invited the participants. The invitees were selected based on the diversity of their views and interests that they represent. In addition, they were selected based on knowledge of their ability to work well within groups and not dominate conversations nor simply speak to position statements to the exclusion of engaging in a dialogue. The initial goal of the exercise was to engage diverse participants in a discussion to exchange knowledge, opinions, and beliefs on the drivers that will shape the future of the ecosystem. The group chose climate change (specifically precipitation changes) and population growth as the major uncertainties (drivers) for designing their narratives about future ecological, social, economic, and cultural states on Lake Ontario and its basin. The four identified Lake Ontario futures independently identified by the groups were

1. Drier Climate- Slow Population Growth: "Boatless Lake Ontario"
2. Wet Climate-Low Population Growth: "Raging Runoff"
3. Drier Climate-Fast Population Growth: "Crowded Beaches"
4. Wet Climate-Fast Population Growth: "Soggy Stripmalls"

Schematic diagrams representing the conditions associated with each scenario were developed to help with the visualization in subsequent dialogs (See **Figure 1**).

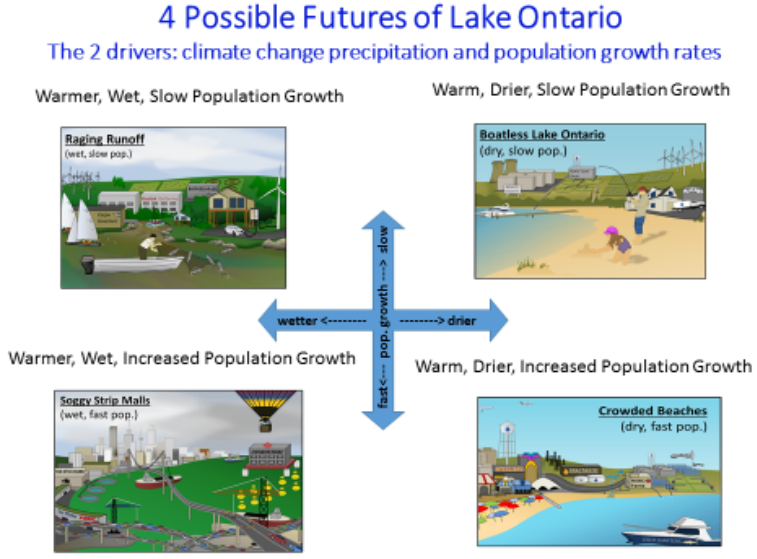

Figure 1: Schematic diagrams representing conditions associated with each scenario to help participants visualize scenarios. .

The goal of this project was to use the four scenarios as a tool in subsequent discussions about recommendations for planning and policy development to address uncertainties related to projected precipitation changes and population growth.

Project Design, Methods, and Engagement

This project was designed to build upon Workshop I, which developed the previously discussed scenarios, as the basis for developing a first round of recommendations for lake and watershed managers in and around Lake Ontario to consider when amending and creating plans to address climate change. The project design included three subsequent workshops: one with invited diverse stakeholders (Workshop II) and the other two (Workshops III-A and B) in areas to attract different segments of the public.

Workshop II was designed to be a two-day event, which would engage similar and overlapping stakeholders from Workshop I. The project team included multi-disciplinary groups from the GLISA, Northeast Regional Climate Center, United States Geological Survey (USGS), Cornell University, and New York Sea Grant. In addition, in order to increase the likelihood of our findings being utilized by state agencies, we invited the New York State Department of Conservation's (NYS DEC) Lake Ontario LAMP Coordinator to join our organizational meetings. Our team included experts in extension, water resources, fisheries, scenario planning, and climate change. **The ultimate goal of Workshop II was to have participants identify a suite of planning actions that were "win-wins" in that they would (a) address issues relevant to multiple stakeholder types and (b) simultaneously help to buffer potential impacts from more than one of the four future scenarios.**

Utilizing these areas of expertise, the agenda for the two-day event had two main components:

Part 1: Setting the Stage:

- Briefly introduce the attendees to scenario planning
- Describe the four scenarios
- Provide examples and technical information on the uncertainties and extremes (precipitation and population changes) and the potential impact on the socioecological system
- Present examples of actions to address climate change adaptation found in plans from other states and locations

Part 2. Participant Development of Recommendations:

- Create four multi-stakeholder subgroups to identify actions which need to be taken today to prepare for each of the potential futures (action, barriers to implementing the action, and ways of overcoming the barriers)
- Bring the groups back together to share findings and identify the common actions identified in all scenarios to form the basis of the project recommendations.

The final product of Workshop II was a deliberated set of stakeholder-driven recommendations for updating the LAMP and local watershed plans to address precipitation and population change impacts and become more resilient **(Table 1).** Once we synthesized the findings from Workshop II, our goal was to verify these findings and ascertain their "acceptability for adoption" through review by two additional independent groups of stakeholders. This was accomplished through inviting the public to attend two evening workshops (Workshops III-A and B) in different areas of the Lake Ontario Basin.

Workshop II

Technical Preparation

The project team met four times, in person and using WebEx, to identify participants and design the agenda, presentations, handouts, and workshop methods. Workshop II, held in May, was scheduled primarily around the academic calendar. Invitations were sent out in March, and our intent was to attract as many of the same stakeholders as possible from Workshop I. The biggest challenge in getting participants for Workshop II was the two-day time commitment. We often received responses about one day suiting but not the other. Therefore, we would decline their participation and include others with the same interests. Our goal was to have a diverse set of participants, which we ultimately attracted. Participants included planning agencies, federal and state agencies, soil and water conservation districts, environmental and sport-fishing organizations, and cooperative extension agents representing agricultural interests. Unlike the first workshop, Workshop II did not have business and tribal representation.

The Northeast Regional Climate Center, New York Sea Grant and Cornell University faculty drafted presentation with technical input from GLISA and designed them to illustrate the science behind precipitation extremes and potential impacts on the ecosystem and human infrastructure.

We originally intended to illustrate precipitation extremes using single case studies of summer 2012 as a dry scenario and summer 1972 as a wet scenario. By using actual case study years from this region, we were able to access real

data including precipitation maps, a drought map, observed and projected annual, seasonal, and event-based precipitation trends, snow cover changes, consecutive dry days, lake level chart, and pictures of local impacts. However, we found limiting our work to individual years constrained the depth of examples we could use. The amount of maps and charts would be reduced, incorporating this information into the examples and including more pictures. Using input from GLISA, additional examples for each scenario were decided on and the presentation was revised. For each example presented, data-driven visuals were accompanied by photographs of impacts. This use of "real-world" data, not "pretend" information, gave considerable credibility to the scenarios and enhanced the engagement of our stakeholders. We considered it particularly important to include a combination of graphs and photographs to help participants visualize and understand the conditions that each scenario represented. It was important that the chosen events and pictures show workshop attendees what the dry and wet scenarios look like and how they could impact the Lake Ontario watershed.

In a similar fashion, our committee team members from Cornell's Dept. of Natural Resources and USGS provided examples of scientifically based but differing potential impacts on coastal and upstream watershed habitats and water quality to ensure the four scenarios present resource changes in substantially different ways. For example, drier conditions could be associated with stream and wetland dry-outs, exposed shorelines at marinas, and dry wells, whereas greater precipitation could be associated with flooding, sediment erosion, and pollution. In this manner, the participants could brainstorm and generate potential actions that cover a wide range of future ecosystem changes. For each scenario, the environmental stressors were explained as well as possible positive outcomes. Pictures and images were included to support these impacts.

To address the finding that climate adaptation is not being integrated into planning efforts across the region (Nelson et al. 2011), the NYSG team reviewed peer and gray literature, web resources, and contacts throughout the basin to identify activities that other Great Lakes communities have taken to integrate climate change uncertainty into their LAMPs or watershed plans. In addition, Sea Grant programs and regional organizations have drafted recommendations and consolidated case studies and tools (e.g. Dinse 2009 and www.greatlakesresilience.org). This 'learning from others' approach prevented duplication of efforts. This work was presented at Workshop II to jump-start participant brainstorming based on examples of strategies used in other locations and similar documents.

Finally, we created and compiled handouts for Workshop II participants, which included copies of scenario examples, overviews of the scenario planning process published by industry and natural resource professionals, and one-page summaries of the assumptions behind each of the four potential future scenarios. In order to visually illustrate the four distinct potential futures, Matthew Paufve , then research technician of USGS, worked with the team to create four detailed images which visually communicated the various aspects of each scenario. The team strove to ensure that the concepts related to scenario planning and the assumptions and key aspects of each scenario were accessible to all participants, regardless of their learning style.

Planning Details

Workshop II was designed to extend over two days to give participants time to know each other, feel comfortable talking and working together, and give them time to mull over the scenario approach and the actual scenarios for which planning was to take place. In this way, deeper thinking went into the recommendations. Group work occurred around each of the scenarios and followed a discussion guide. Attendees were given handouts of their respective scenarios, including descriptive artwork and main points. Flip charts and markers were the primary tool for gathering input. We noted that our work would have been reduced if we had taken notes on computers as opposed to the flip-charts. In hindsight, using both would have been the preferred approach. Each group was established by the facilitation team prior to the event to try and ensure for diversity of interests and expertise in each group. Each group included at least one subject matter expert (Bunting-Howarth—policy; Weidel—fisheries and scenario planning; MacNeill—fisheries; Spaccio—climate science; Schneider—natural resource and watershed processes and management) who was a planning team member assigned to facilitate the discussion utilizing a discussion guide. Each group was charged to create recommendations for what decision-makers should do today to prepare for the assigned potential future scenario (noting that we would focus on recommendations for LAMP and Watershed Plans).

Breakout sessions occurred on both days for a total of 3.5 hours. The key questions were:

1. What do you think we should do today to be more prepared for that potential future?

2. What are the barriers to implementing that action? What are ways around the barrier?
3. What are the secondary benefits from taking that action?

After this first round of brainstorming, the groups were reconvened to share recommendations, barriers, and ways of surmounting barriers. The next step was critical. The group then identified common actions—a deliberated set of stakeholder driven recommendations for updating the LAMP and local watershed plans—topics, and potential venues for presenting information generated at the workshop.

Outcomes

The groups generated approximately 100 different recommendations, which could be grouped into five broad categories of water resource management, infrastructure, planning and zoning, water-related businesses, and ecosystem management **(Table 1).** Recommendations also encompassed the full range of types of strategies from education to regulations. Some very powerful recommended actions were identified as providing good solutions to address the extremes of all four scenarios. For example, improved capture of stormwater runoff with increased infiltration and groundwater recharge would help reduce both the problems of flooding and droughts and increase water availability with population growth. Such win-win solutions rank as high priorities for immediate planning action. Other recommendations of note include better water and stormwater management, riparian buffers, wetland and stream hydrology restoration, infrastructure improvement and relocation, and social recommendations related to governance and linking job training to energy and environmental actions. In order to more concisely package the recommended actions, implementation mechanism, and opportunities for overcoming barriers to implementation, we created a summary matrix. (See **Table 1**: Summary of "Win-Win" Recommendations.)

Workshop III

In November 2015, the final series of public engagement, Workshops III-A and B, were held at opposite ends of the lake basin. The audience consisted of interested (and diverse) members of the public that included lake side residents, environmental action groups, anglers, boaters, a state and county legislators, environmental management agencies, water quality coordinating committees, and other concerned citizens. For both of these workshops, open public attendance was the focus. These workshops were organized to gather public input on these recommendations to be presented to State and Federal agencies on how to address uncertainties related to extreme precipitation patterns and population changes in lake and watershed management plans. Workshops III-A and B were held in the evening and in geographically different parts of the watershed (Rochester and Watertown) with the hope that a more diverse representative public could attend. We released a press release, which was picked up by twenty-eight local papers and other media outlets. In addition, information about the Workshops was publicized via the Great Lakes Information Network and the Great Lakes Action Agenda, held by NYS DEC. Twitter and Facebook were also used to publicize the workshops.

Workshops III-A and B were designed to briefly share the uncertainties related to precipitation due to climate change and its impacts on our socioecological system and then present the synthesized recommendations from Workshop II. The group was given about an hour to rotate through five stations. Each station had its own theme: water resource management, infrastructure, water dependent business, land use/zoning, and ecosystem management. At each station, groups were asked to discuss the actions, add additional actions, or modify existing actions/recommendations. Flip charts and markers were again the primary tool for gathering input. Posters of the recommendation summary table (**Table 1**) were made and displayed at each station. At the conclusion, the groups were asked to prioritize all of the presented recommendations. They used sticky dots to denote one recommendation at each station they felt was the best.

Overall, Workshops III-A and B validated the key action items identified in Workshop II. The prioritization exercise highlighted actions within each of the categories identified in Workshop II (water resource management, infrastructure, planning and zoning, water-related businesses, and ecosystem management). In addition, Workshops III-A and B highlighted additional areas for inquiry — specifically related to onsite wastewater treatment and disposal systems.

Lessons Learned/Key Findings

Overall, we found that the scenario approach provided a powerful tool for engaging stakeholders into thinking and planning for a future (more than just 2-3 years in

advance). By identifying realistic scenarios of wetter-drier climate and faster or slower development, they accepted these situations and "bought in" to the process. The combination of real data, photographs of case study historical years, the scenario icons, and name for each scenario all provided a key mechanism for reaching all the different learning types of the diverse participants so that everybody understood and could participate. One of the key weaknesses of communicating complex, technical information which has been identified previously is that scientific jargon is often incomprehensible to non-scientific audiences, hence their lack of engagement, let alone adoption. Finally, we were delighted with the number of recommended actions, the breadth of the types of actions, and in particular with the identification of those win-win actions that would be useful in the face of uncertainty.

One takeaway from this project is that when using a scenario planning process, the timeline for implementation must be accomplished over a shorter time period with the same people. Team observations participant feedback support this claim. For instance, participant comments included:

- Creation of scenarios (Workshop I) vs actions to address scenario (Workshop II) shouldn't be a split process.
- Adaptation workshop too "scenario focused." Focus should be on outcome/activity.
- Participants felt restricted by scenario (because they did not develop it). Groups wanted to go back to beginning.
- It would have improved the process if more people from Workshop I were present at subsequent workshops.

Working through these diverse future scenarios, the groups created a set of recommended actions that many believed communities should be engaging currently. This was one point of the exercise—to create a list of "win-win" actions to take today to prepare for tomorrow. This "Ah-Ha" moment was expected. Comments that support this include:

- Group ended up with a list of what we should already be doing.
- There was much convergence of actions among scenarios.

Another lesson was that the process does not always lead to having all areas for action being addressed. However, the results were to only be used as a starting place for lake and watershed managers. From Workshop II, participants identified the following gaps in the list of adaptation recommendations:

- Energy (discussed but did not rise to top)
- Connecting ecosystem health to human health
- Need for climate modeling, monitoring, and improvements
- Risk assessment/vulnerability
- International effects
- Technology transfer
- Climate Change disproportionately impacts poor and aging

Workshops III-A and B gave a local perspective on the recommendations. There was consensus and prioritization of items from Workshop II:

- Discourage living in vulnerable areas and encourage development of existing urban areas
- Revise zoning based on ecosystem management
- Broader governance approaches and inter-municipal agreements
- Learning and incentives for green infrastructure
- Need for better and cheaper monitoring programs
- Need for research and technology in agriculture

In addition, their work highlighted recommendations that may have been discussed in break-out sessions during Workshop II but not highlighted as priorities:

- Pay attention to projects in the headwaters
- Add septic system maintenance and inspections
- Connect communities through greenways
- Emphasize preventing invasive species

Attendees of Workshop III echoed concerns of Workshop II, that there was too much time spent following the process and the scenarios. They would have liked more detail, explanation, and time with the recommendations. This is supported by several comments:

- Some recommendations from previous workshop too general
- More helpful if recommendations presented before workshop
- Content and scope overwhelming for someone with little background
- Add glossary of terms

Finally, although our initial goal was to generate recommendations for the LAMP and Watershed Plans, many of the recommendation were not those typically associated with the LAMP and were more appropriate for watershed planning and management. However, this does not mean that the recommendations are not relevant to the LAMP planning process. The exercise highlighted the importance of land-based activities on the health of the lake as well as the how the lake impacts the communities

and people located along the shore and upstream in the basin, a message worth conveying to LAMP managers.

Applicability to future work and other efforts in the region

The scenario planning process used could be used in other areas, although we would recommend going through the entire process in a shorter time period. When undertaking the entire scenario planning process, climate change would not have to be identified as one of the axes of uncertainty in designing the four scenarios. However, the phase of having groups design plans for these potential futures could be done with specific climate change impacts as the context for developing the recommendations. One issue cannot be planned for in a vacuum. Especially, when considering climate change, impacts to human and natural infrastructure, population, disease, natural species, etc. are all interconnected. Processes such as scenario planning can not only build an appreciation for the uncertainties in our world, but for the interconnectedness of all aspects of the socioecological system (Walker et al. 2002; Peterson et al. 2003).

In addition to a more condensed timeframe with the same participants, a smaller watershed than an entire Great Lake basin should be used. For our purpose, the generated recommendations were broad as our need was to create recommendations applicable to many settings: Lake Ontario, its Basin, and individual sub-watersheds. However, more refined and place-based recommendations could be developed for a smaller area with less diversity in terms of ecology, socioeconomics and political entities.

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Table 1: Summary of Recommended Actions

	Water Resource Management	Infrastructure (transportation, wastewater, drinking water, stormwater)	Land Use Planning, Zoning & Governance	Water Dependent Businesses (Agriculture, Tourism, Boating & Fishing)	Ecosystem Management
ACTION ITEMS	Manage stormwater for quality and quantity Allocate water use Provide for storage (natural and man-made), green-infrastructure approaches	Prioritize upgrades, improvements and relocations (out of flood plains) Design and site with growth in mind Develop standards and alternate systems (green infrastructure, alternate transportation modes) Real cost pricing for water	Revitalize urban core to reduce infrastructure cost through concentrating population Discourage living in vulnerable areas Encourage open space for water recharge and storage Promote use of brownfields Promote research & development of new technologies and develop industries & jobs related to new technologies Provide additional resources for vulnerable populations	Align funding opportunities at state and federal level with needs Integrate agricultural practices with energy needs (such as biomass) Consider increased greenhouse production Store water for potential droughts Invest in science to determine best recreational species for long-term stocking Enhance recreation/tourism industries via new programs	Create and enhance systems for early detection & response of invasive species (pest, plant, animal, aquatic) Increase early detection of new pathogens Stream and wetland restoration and other methods to restore hydrology Protect, enhance & restore riparian buffers
Regulatory Policy	Develop, implement, revisit allocation rules Revisit rules and policies to allow for more innovation in engineering standards	Revisit rules and policies to be more adaptive to new technologies, technique and design standards Update design criteria for future conditions & allow for innovations	Local laws, ordinance, taxation review for resilience to extreme weather Infrastructure development policy to manage growtih	Amend Farm Bill to meet sustainable farming needs	
Education Outreach	Needed	Needed	Needed	Needed	Needed
Funding	Consider charging for the true cost of water State grant programs	User fee for transportation True cost water	Bonds, grants	Federal and state cost-share and grants Tourism	Cost-share; state funding
Engineering standards and R&D	Needed	Needed	Needed	Needed	Needed
Governance	Consider inter-municipal agreements Encourage service consolidation among local governments	Consider inter-municipal agreements Encourage service consolidation among local governments	Home rule Consider inter-municipal agreements, coordination, consolidation		
Monitoring	Monitoring programs for waterways & stormwater (quality and quantity)	Fund inspection programs to assist in the prioritization of upgrades and relocations			Monitoring programs for detection of invasive species & pathogens