

Benefits to human health from improving Great Lakes ecosystem services

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GREAT LAKES RESTORATION INITIATIVE

ACTION PLAN III

Fiscal Year 2020 - Fiscal Year 2024

The Great Lakes Restoration Initiative Accelerates Great Lakes Protection and Restoration in Five Focus Areas

FY 2010 – FY 2014: GLRI Action Plan I	FY 2015 – FY 2019: GLRI Action Plan II	FY 2020 – FY 2024: GLRI Action Plan III
Toxic Substances and Areas of Concern		
Invasive Species		
Nonpoint Source Pollution Impacts on Nearshore Health		
Habitats and Species		
Foundations for Future Restoration Actions		

Long-Term Goals for the Great Lakes Ecosystem

- All Areas of Concern delisted
- Fish safe to eat
- Water safe for recreation
- Safe source of drinking water
- No new self-sustaining invasive species
- Existing invasive species controlled
- Harmful/nuisance algal blooms eliminated
- Habitat protected and restored to sustain healthy ecosystem function and native species




Canadian and U.S. Areas of Concern in the Great Lakes Basin



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Evaluating Great Lakes Area of Concern Restoration

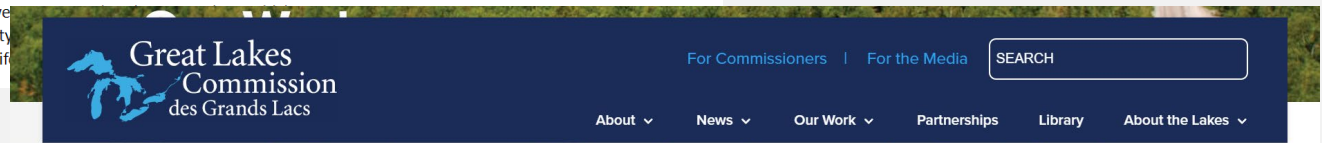
What have we achieved and learned after more than 30 years of Remedial Action Plans to restore Great Lakes Areas of Concern?

In 1985, the eight Great Lakes states, Ontario, and the U.S. and Canadian federal governments committed to developing and implementing comprehensive remedial action plans (RAPs) to restore impaired beneficial uses in Great Lakes Areas of Concern (AOCs). In 1987, this commitment was codified in a Protocol to the Canada-U.S. Great Lakes Water Quality Agreement.

In 2017, a symposium titled "Restoring Great Lakes Areas of Concern" was convened at IAGLR's Conference on Great Lakes Research in Detroit. Twenty-seven papers and five posters were sponsored by the Aquatic Ecosystem Health & Management Society, the Great Lakes Commission, and the Detroit River International Wildlife Refuge.

Case Studies

- [1. River Raisin Area of Concern](#)
- [2. Detroit River Area of Concern](#)
- [3. Severn Sound Area of Concern](#)
- [4. Collingwood Harbour Area of Concern](#)
- [5. Hamilton Harbour Area of Concern](#)
- [6. Muskegon Lake Area of Concern](#)
- [7. Cuyahoga River Area of Concern](#)
- [8. Buffalo River Area of Concern](#)




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Economic Development & Waterfront Community Revitalization

The unique freshwater resources of the Great Lakes fueled the region's early development, with waterfront areas historically serving as centers of economic activity. However, the industrialization and development of the basin over the past 200 years has had an impact on the ecological health of the lakes. Currently, many coastal communities are working to restore and reclaim waterfronts and leverage fresh water assets to promote economic growth, support water-dependent industry, and sustain a high quality of life in the Great Lakes region. The Great Lakes Restoration Initiative is accelerating this process, particularly in the region's worst toxic hotspots. With its member states and provinces, the Great Lakes Commission is working to support the revitalization of waterfront communities and support water-dependent economy through research, policy development, information exchange and technology transfer, and stakeholder collaboration.



Remediation to Restoration to Revitalization (R2R2R) Framework

To help transform remediation and restoration projects into sustainable revitalization of the surrounding community by maximizing the positive societal and environmental outcomes

Restoration & Revitalization



Managing Contamination
Partnering companies purchased a 19-acre parcel in Ashtabula Township for a Sediment Consolidation Facility, where contaminated sediments from the riverbed would be stored. This facility was completed in 2006.

State and federal agencies implemented dredging of the Ashtabula River between 2006 and 2011, removing over 700,000 cubic yards of contaminated sediment from the river and reopening it for commercial shipping and recreational boating. The contaminated material was pumped into a specifically designed landfill and isolated from the environment.



Restoring the River
Restoration of the Ashtabula River began in 2008. About 2,500 feet of fish shelves and a total of 10.5 acres of river, wetland, and upland habitat were created, providing a home for mammals, birds, and fish.

Through the efforts of many, the Hish-tah-buh-lah River is returning to its former glory as a "river of many fish."

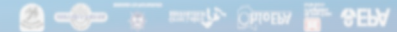


Using funds from the US EPA, U.S. A.C.E., industry and the State of Ohio, approximately 700,000 cubic yards of contaminated sediment were removed from the river between 2006 and 2010, pumped uphill through a 2.5 mile pipeline to a specially designed containment facility, and into geotextile tubes, bags that separate contaminated sediment from the dairy water.

The Ashtabula River Partnership: A model approach to environmental cleanup



The Ashtabula River Partnership: A model approach to environmental cleanup



Ecosystem Services

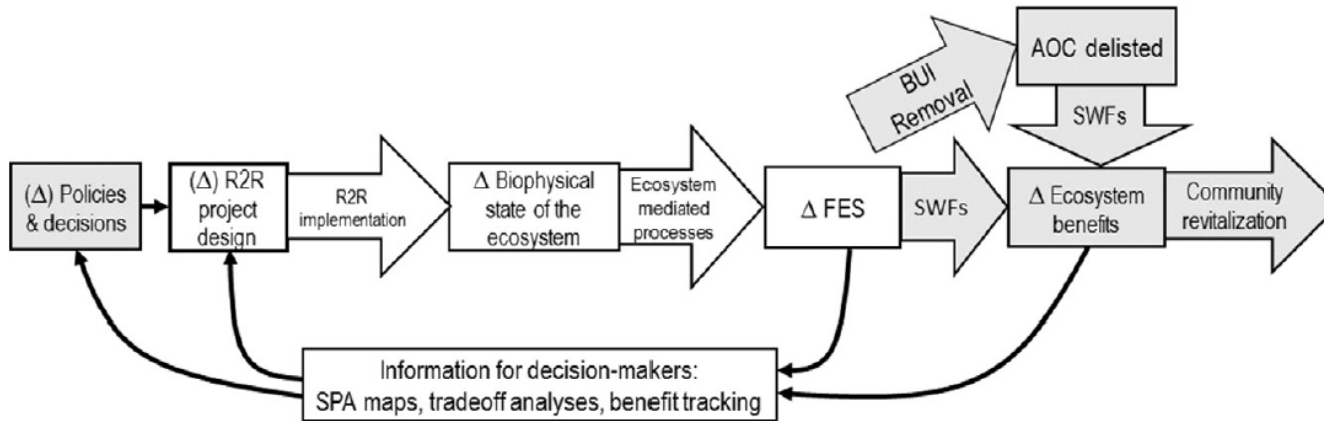
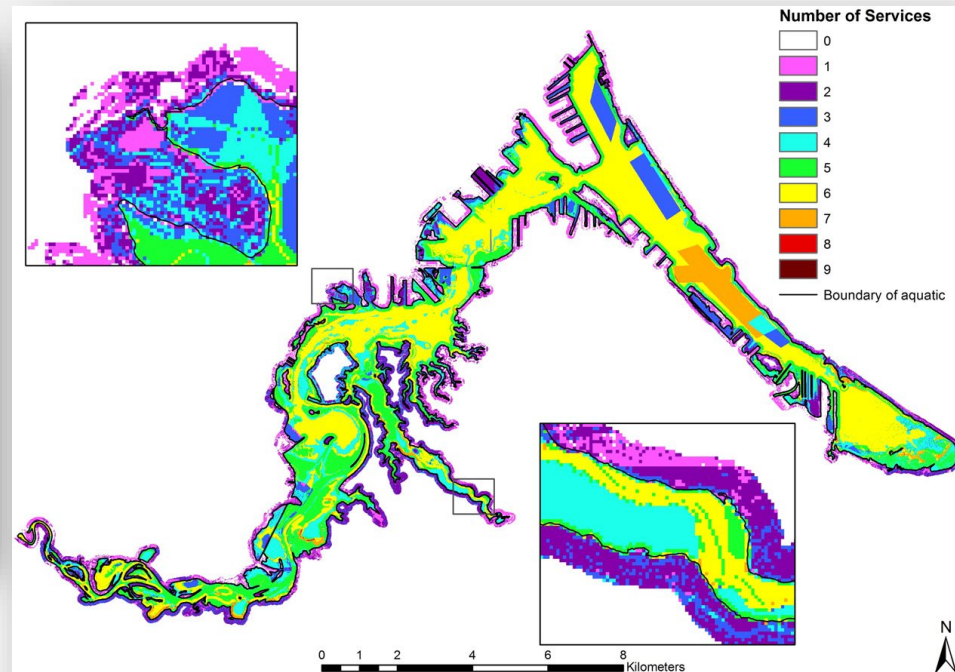
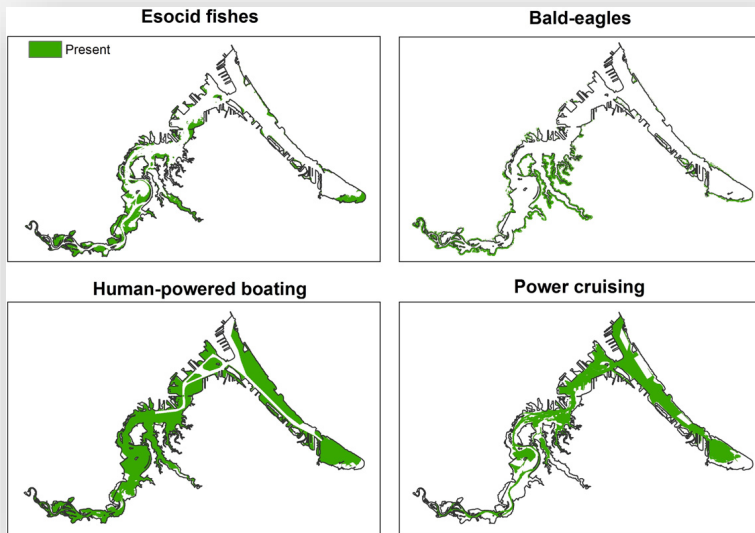


Fig. 2. Conceptual framework for the use of ecosystem service mapping and associated analysis to support decision-making in an estuarine Great Lakes AOC. This paper is primarily concerned with the unshaded parts of the framework. R2R = remediation to restoration; FES = final ecosystem services; BUI = beneficial use impairment; AOC = area of concern; SPA = service providing area, SWF = social welfare function.



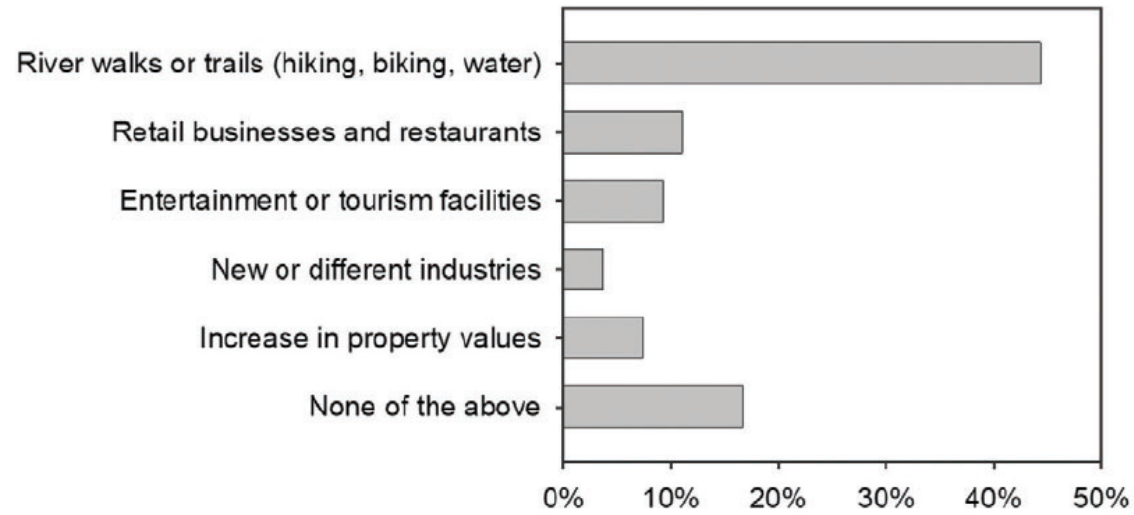


Figure 1. What changes have you witnessed in the land use adjacent to your AOC? (n=54, two responses allowed).

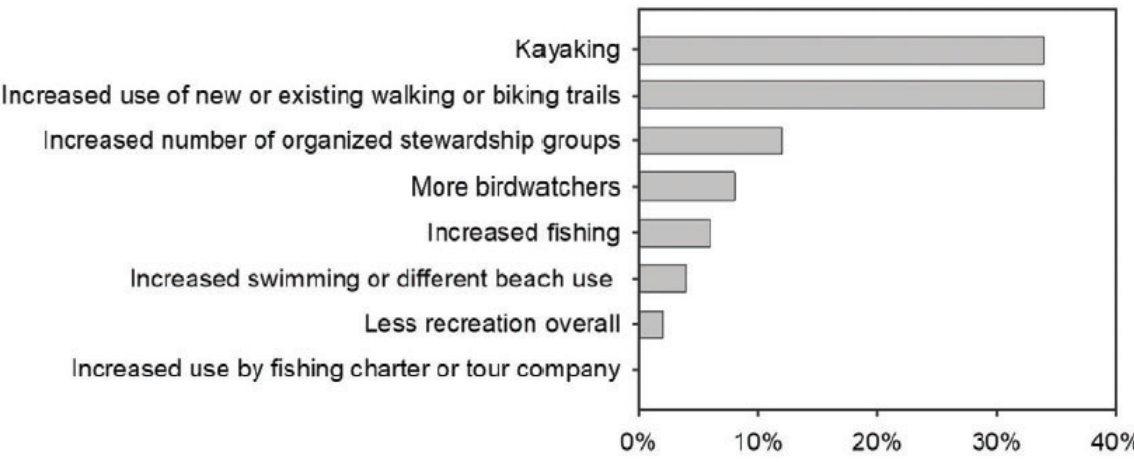
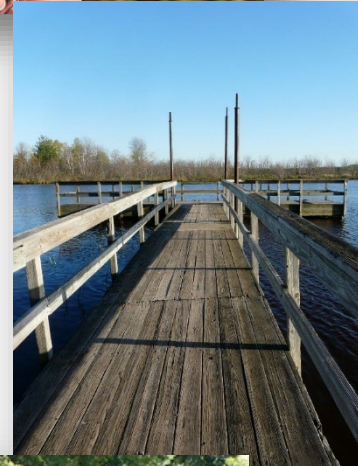


Figure 2. What changes in recreational use have you noticed in your AOC? (n=50, two responses allowed).

R2R2R as a Social-Ecological System

- Ecosystem-based
- Ecosystem services ~ environmental quality, ecological health
- Beneficiaries
- Stakeholder engagement, data co-production
- Feedback loops
 - Between Rs
 - Adaptive management
 - Social change



Research Goals

“Thus, the result of environmental restoration and outcomes is ultimately social and cultural well-being, identity, and quality of life.”

Williams et al., 2022

- Removing impairments will benefit the community
- Few empirical or synthesis studies to demonstrate this
- Literature-reviews of existing health studies that are directly related to the 14 BUIs
- Characterize array and magnitude of health benefits

epa.gov/enviroatlas



What are the public health benefits of addressing beneficial use impairments (BUIs)?

	Beneficial Use Impairments	Group
*	Degradation of Aesthetics	1
	Loss of Fish and Wildlife Habitat	1
*	Eutrophication or Undesirable Algae	2
	Restrictions on Drinking Water Consumption/Taste and Odor Problems	2
	Beach Closings	2
	Degraded Fish and Wildlife Populations	3
	Fish Tumors or Other Deformities	3
	Bird or Animal Deformities or Reproductive Problems	3
	Restrictions on Fish and Wildlife Consumption	4
	Tainting of Fish and Wildlife Flavor	4
	Degradation of Phytoplankton and Zooplankton Populations	5
Degradation of Benthos	5	
	Added Costs to Agriculture or Industry	6
	Restrictions on Dredging Activities	7

Improving Aesthetics of Green and Blue Spaces

- Address degradation
 - Slicks, sheens, foams, colors, turbidity, odors, debris, litter
- Attract people to places
- Ultimately, improve ecological and human health
 - Direct connection
 - Indirect connection (via EGS)
 - Cumulative and indirect effects



Systematic Review

- Based on search terms
- Screening
 - Exposure is aesthetics-related
 - At least one health outcome
 - Original study
- Extraction
 - Study design
 - Methods
 - Exposure/Outcome
 - Effect size

Degradation of Aesthetics Related Terms

degradation of aesthetics
water clarity
water color
water debris
marine plastic
marine litter
marine debris
blue space
bluescape
linear park
loss of fish/wildlife habitat
turbidity
recreational use/services
litter/trash
waterway/water
perceived/perception of
aesthetics
beach aesthetic pollution
aesthetic quality
clean beaches
beach litter
clarity score
odor/odour
aesthetic value
aesthetic quality index
visual quality

Health Outcome Related Terms

stress
mental health
gastrointestinal
obstruction/illness
laceration
acute infection
calm
restorative
emotional benefit
cardiovascular
recreation
physical activity
social connection/interaction
obesity
cancer
injury

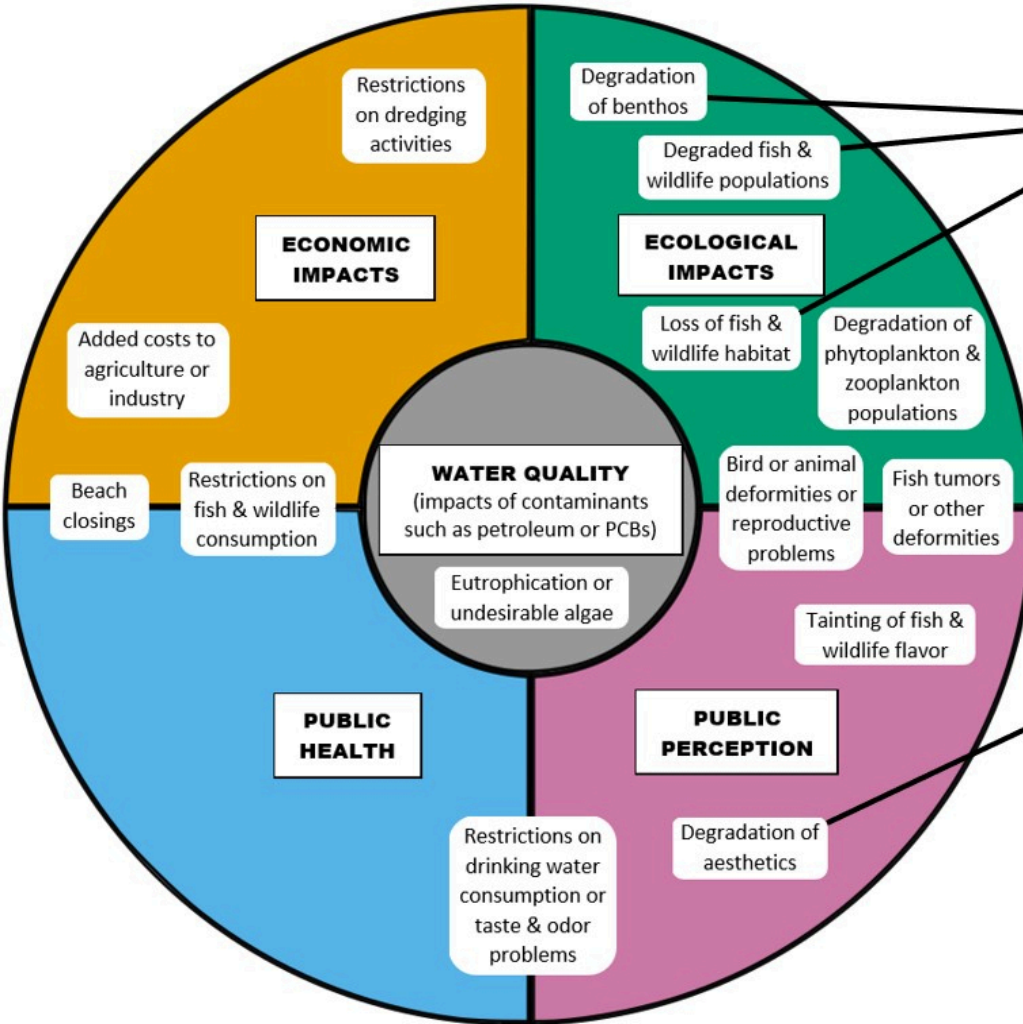
Results

- Evidence for positive effect of exposure to “natural” spaces
 - Self-reported health
 - Physical activity
 - Alzheimer’s Disease
 - Depressive symptoms
 - Suicide mortality
 - Mood/anxiety disorders
 - Mental health (various tools)
 - Wellbeing
- Evidence for negative effect to exposure to poor quality spaces
 - Injury (litter)
- Multiple studies found weak or no effects



Impacts on Disease Transmission

Beneficial Use Impairments (BUIs)



Impacts on Mosquitoes & Disease Transmission



- Lower populations of fish and benthic macroinvertebrate predators could allow populations of *Culex pipiens* mosquitoes to grow.
- This could increase the risk of West Nile virus (WNV) transmission to humans.



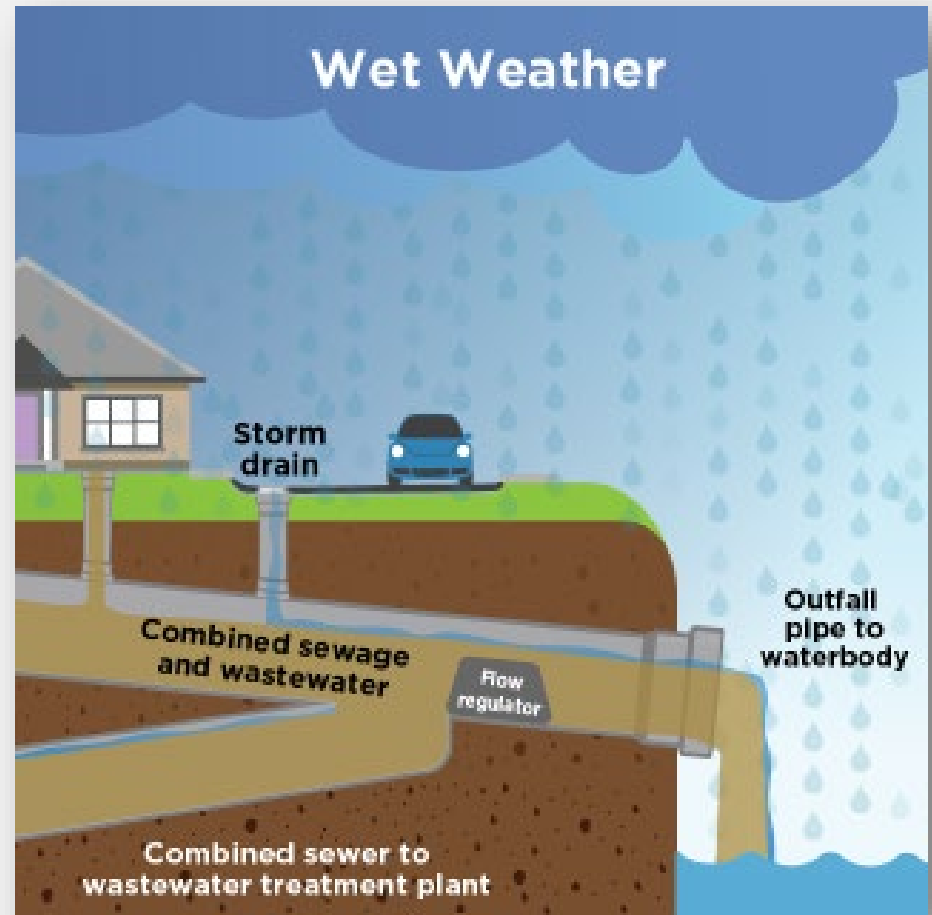
- Higher amounts of beach litter could increase the number of small artificial containers where *Aedes albopictus* and *Aedes aegypti* mosquitoes lay their eggs.
- These species can transmit dengue, chikungunya, yellow fever, and Zika to humans.

Role of Climate Change

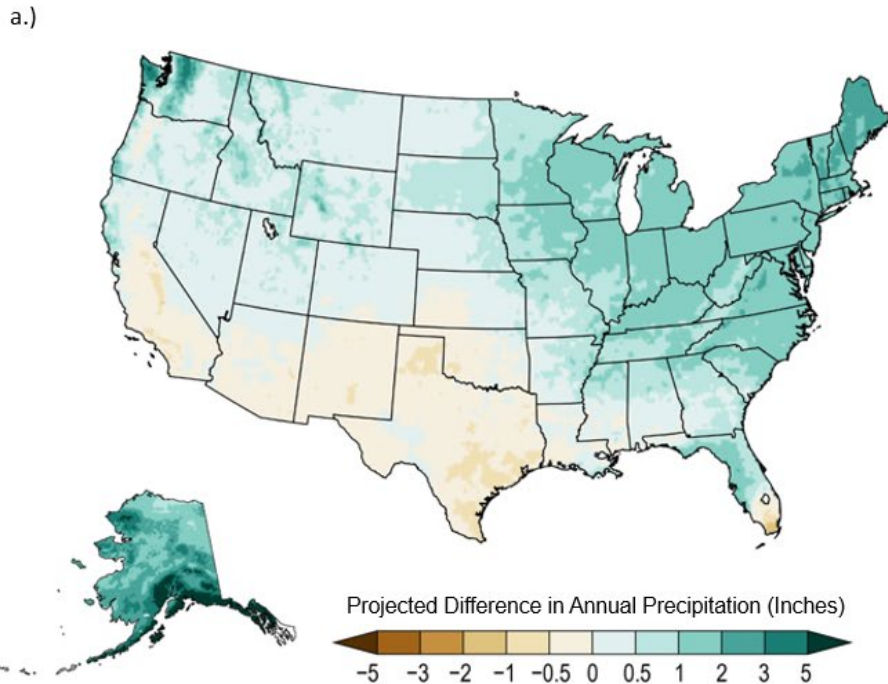
- WNV spillover to humans is more likely during drought conditions.
- Storm surges that are larger and may target new coastal areas are likely to create pools of standing freshwater - ideal habitats for mosquito development.
- The geographic ranges of *Aedes albopictus* and *Aedes aegypti* mosquitoes are predicted to expand further northward.

Addressing Combined Sewage Overflows (CSOs)

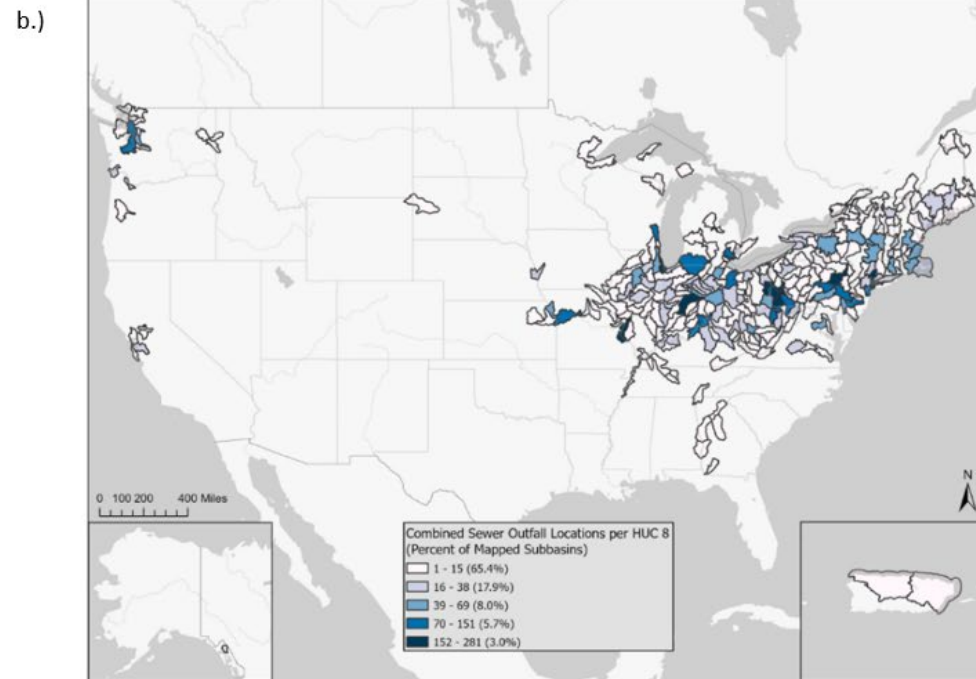
- Relationship between rainfall and gastrointestinal (GI) illness is well-studied but association varies widely
- CSO events likely mediate the association
- Extreme precipitation events are predicted to increase
- We conducted a comprehensive review of studies that investigated a potential association between CSOs and GI health outcomes.



CSOs Remain a Widespread Concern



a) Average projected changes in annual precipitation by midcentury (2036-2065 relative to 1991-2020)



b) Locations of permitted combined sewer outfall locations, 20 grouped spatially by watershed subbasins, Hydrologic Unit Code 8

Systematic Review

Exposure	Health Outcome
extreme precipitation, extreme rainfall, high precipitation, sewer overflow, sewage overflow, overflowing water, persistent extreme precipitation, precipitation extremes, rainfall intensity, rainfall extremes	<u>Gastrointestinal:</u> diarrhea, vomiting, abdominal pain, gastrointestinal illness, ulcer, jaundice, liver disease, liver damage, hepatic toxicity, liver hemorrhaging, inflammatory bowel disease, ulcerative colitis
	<u>Cardiovascular:</u> cardiovascular disease, heart disease, hypertension, stroke, lipid dysregulation, cholesterol levels, pregnancy-induced hypertension, pre- eclampsia, hematological damage, cardiopulmonary mortality, ischemic heart disease, chronic heart disease, cerebrovascular disease, chronic rheumatic heart disease, myocardial infarction
	<u>Neurological:</u> central nervous system damage, muscle twitching, paresthesia, paralysis, vertigo, dizziness, headache, seizure, epilepsy, chronic neurologic effects, ALS, amyotrophic lateral sclerosis, Parkinson's disease, dementia, Alzheimer's, palsy, ataxia, neurological disorder

- Based on search terms
- Screening
 - Exposure is CSO-related
 - At least one health outcome
 - Original study
- Extraction
 - Study design
 - Methods
 - Exposure/Outcome
 - Effect size

Russell et al., in review

Results





Conclusions

Improved environmental quality can yield a wide variety of health benefits

- Aesthetics: potential for improved physical health, mental health, and reduced disease and mortality
- CSOs: reduced GI illness through recreation and drinking water pathways
- Our interdisciplinary team will continue to conduct systematic reviews and use the AOC program as case study

Questions?

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