Fred A. and Barbara M. Erb Family Foundation

WATER CENTER
UNIVERSITY OF MICHIGAN

Great Lakes Environmental Assessment & Mapping

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Penultimate Report - July 20, 2015

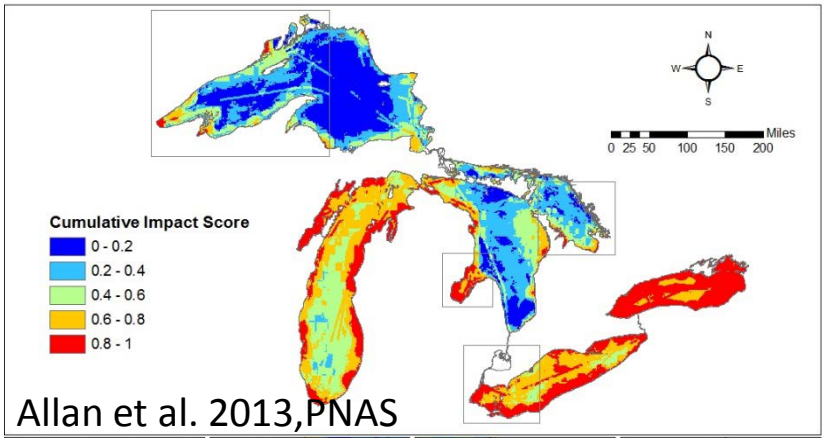
Context: Research Questions

- GLEAM 1
  1. What are the cumulative effects of important stressors affecting the GL and how do they vary across the basin?
  2. What is the relationship between stressors and benefits?
- GLEAM 2
  1. How concordant are GLEI and GLEAM stressor maps with one another and with lake condition indicators?
  2. How important are interactions among stressors in determining cumulative stress?
  3. How can we make stressor and benefit mapping useful to managers and other end users?

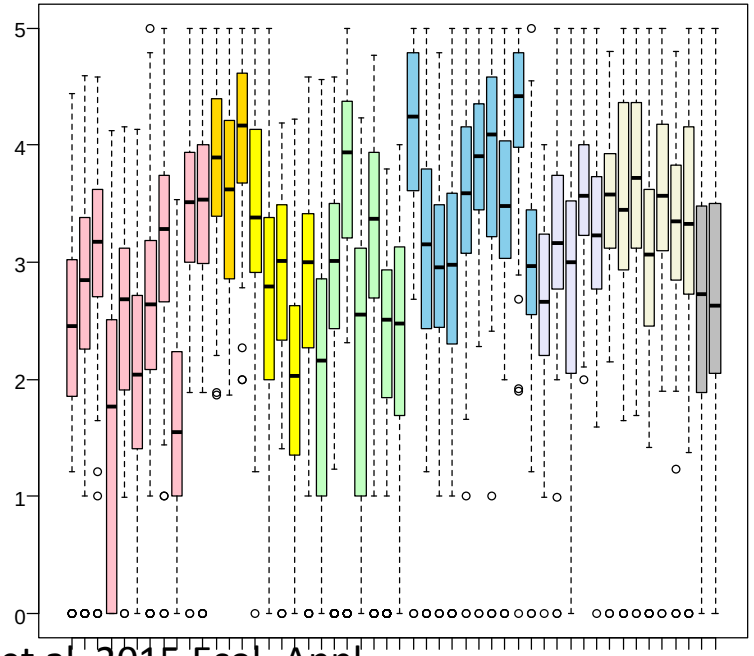
Context: Broader Implications

- Living in a multi-stressor world (Bails et al. 2005)
  - Need to find balance between identifying top priorities and recognizing that dozens of stressors may be important
- Stressors, both individual and cumulative, vary a lot from place to place
  - Need to appreciate that individual locations may experience a particular suite of challenges
- Integrating benefits into planning
  - While protecting and restoring the GL is the rationale for virtually all management activity, not all locations provide the same benefits

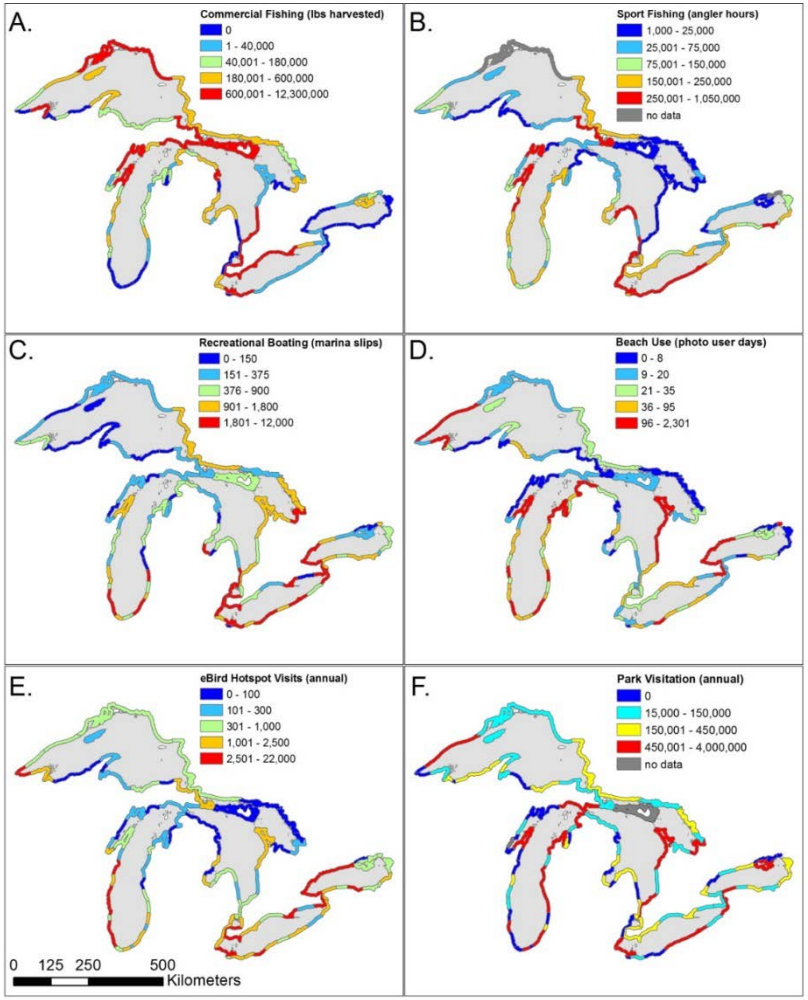
Project Outputs - Completed



Allan et al. 2013,PNAS



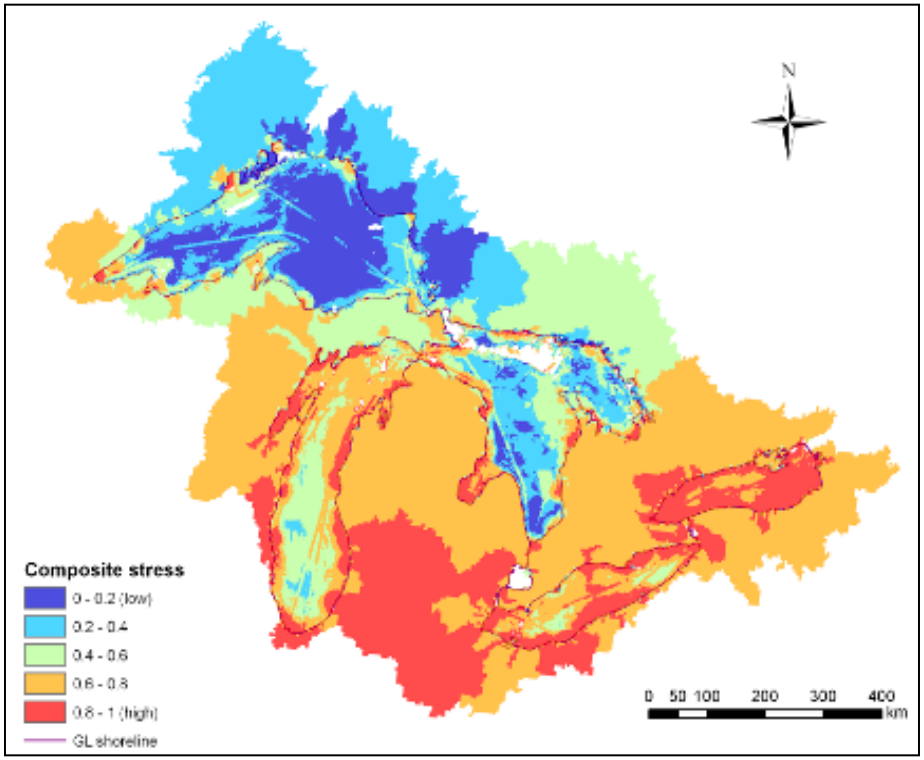
Smith et al. 2015,Ecol. Appl.



Allan et al. 2015, Frontiers in Ecology & the Environment

Outputs: GLEI-GLEAM Concordance

- How concordant are GLEI and GLEAM stressor maps with one another and with lake condition indicators?



Integrated composite stress maps for the Great Lakes basin.

Composite stress scores were derived from five land variables of GLEI project and 34 lake stressors of GLEAM project. Stress scores were normalized for entire basin.

Further progress is described by L. Johnson

Outputs: Stressor Interactions

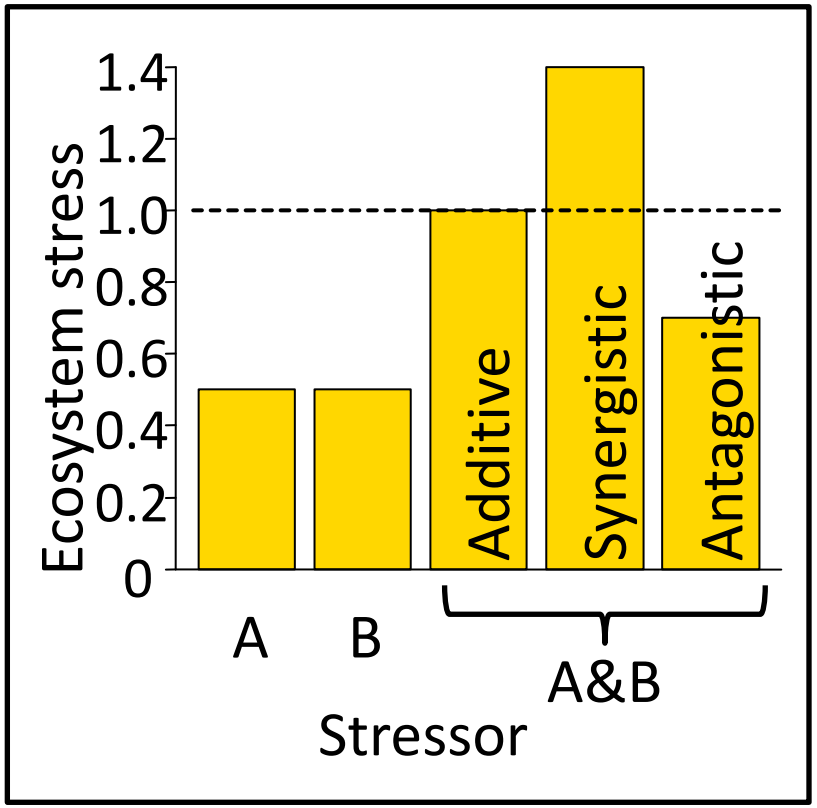
- How important are interactions among stressors in determining cumulative stress?

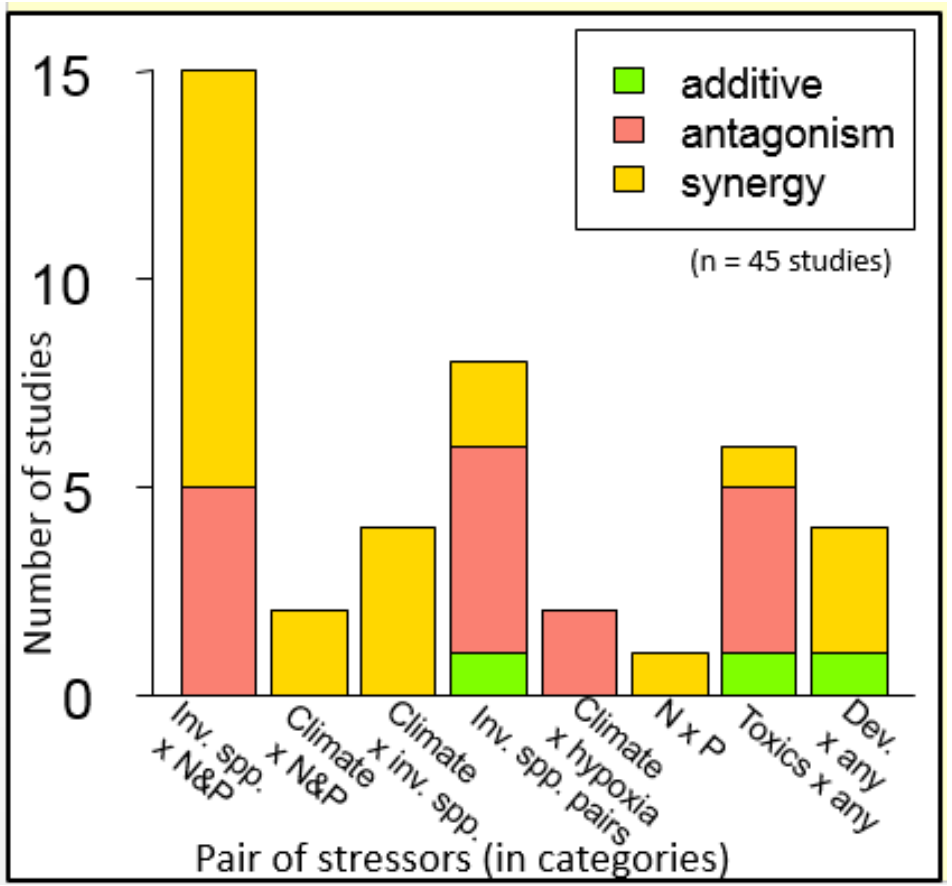
- From expert knowledge, eutrophication and climate change likely drive several important interactions

Stressor pair	Type
Climate change impacts x P loading	Synergy
Coastal dev. x N & P loading	Synergy
P loading x invasive mussels	Synergy
P loading x hypoxia	Synergy
Climate warming water temperature x hypoxia	Synergy
Tributary dams x sediment loading	Antag.
Coastal dev. x changing water levels	Either

Outputs: Stressor Interactions

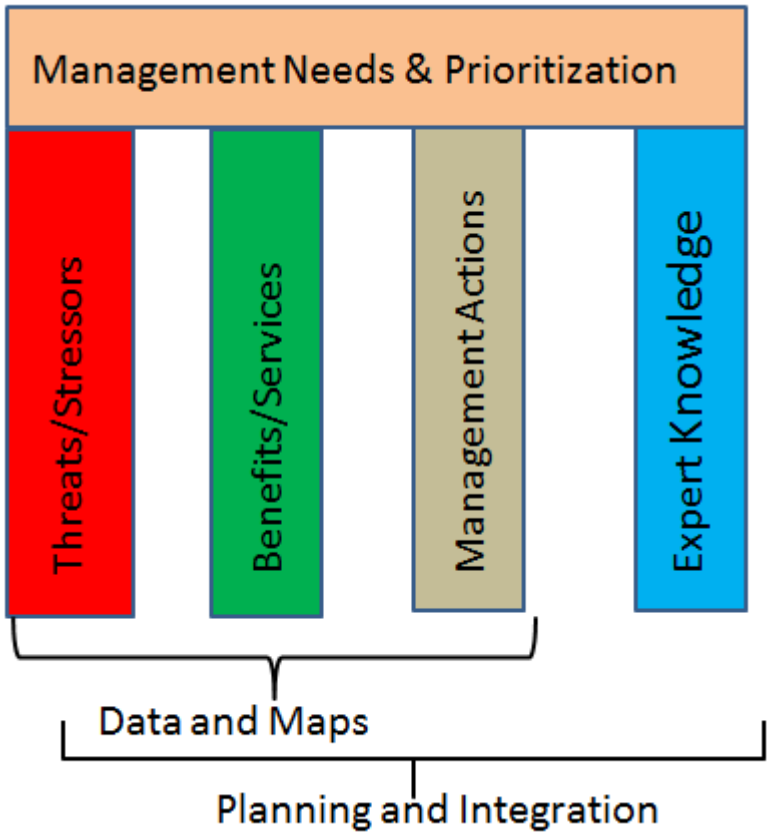
- How important are interactions among stressors in determining cumulative stress?
- From literature review, antagonisms appear to be at least as common as synergies

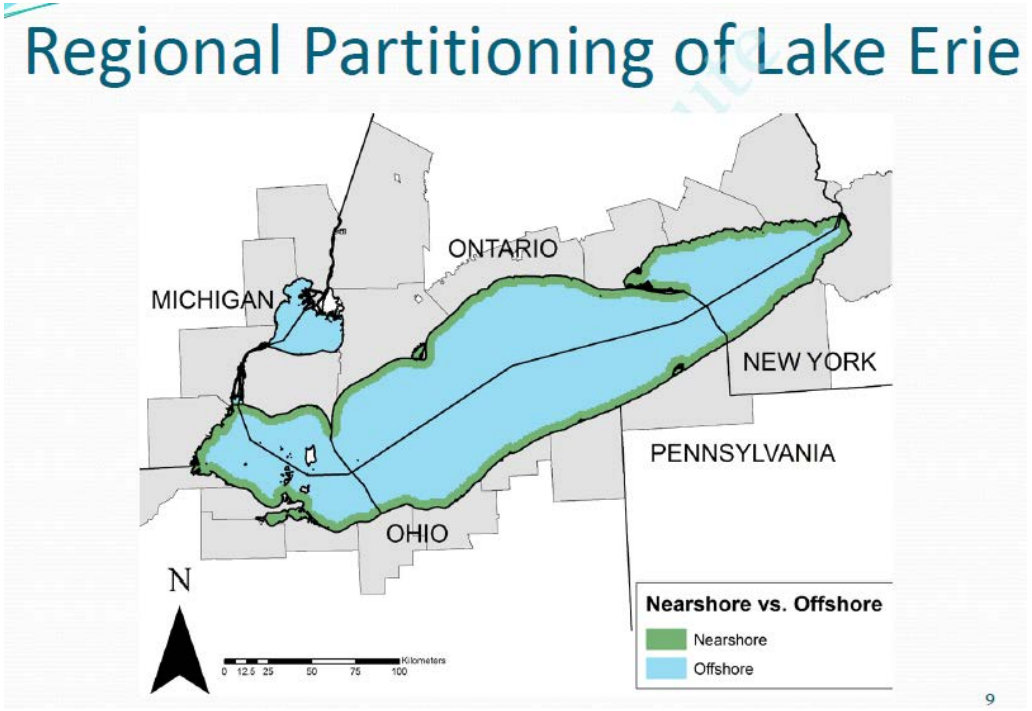




Outputs: Lake Erie Prioritization

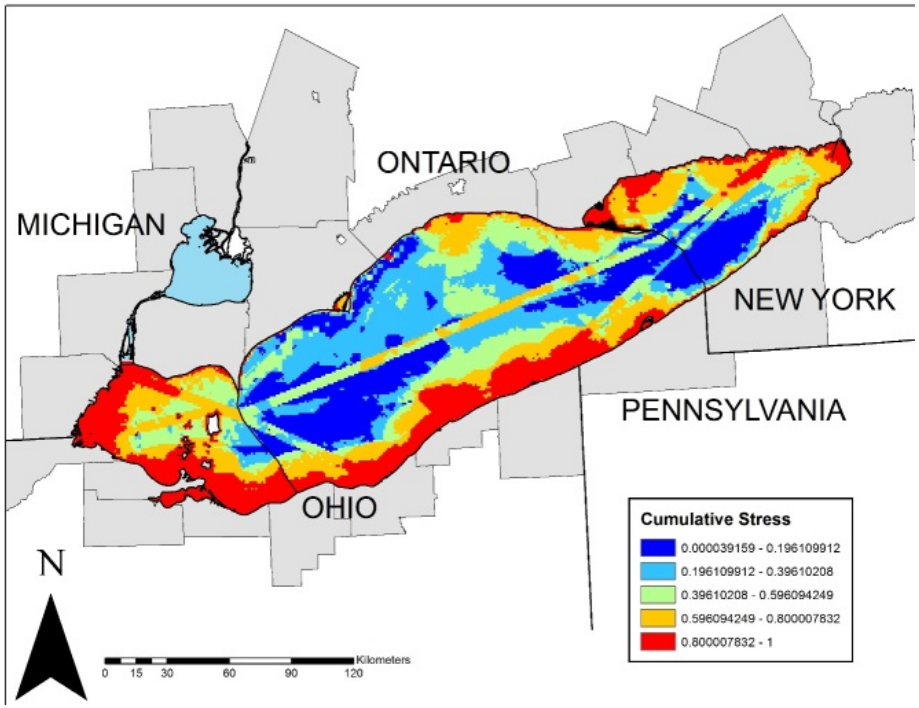
- How can we make stressor and services mapping useful to managers?





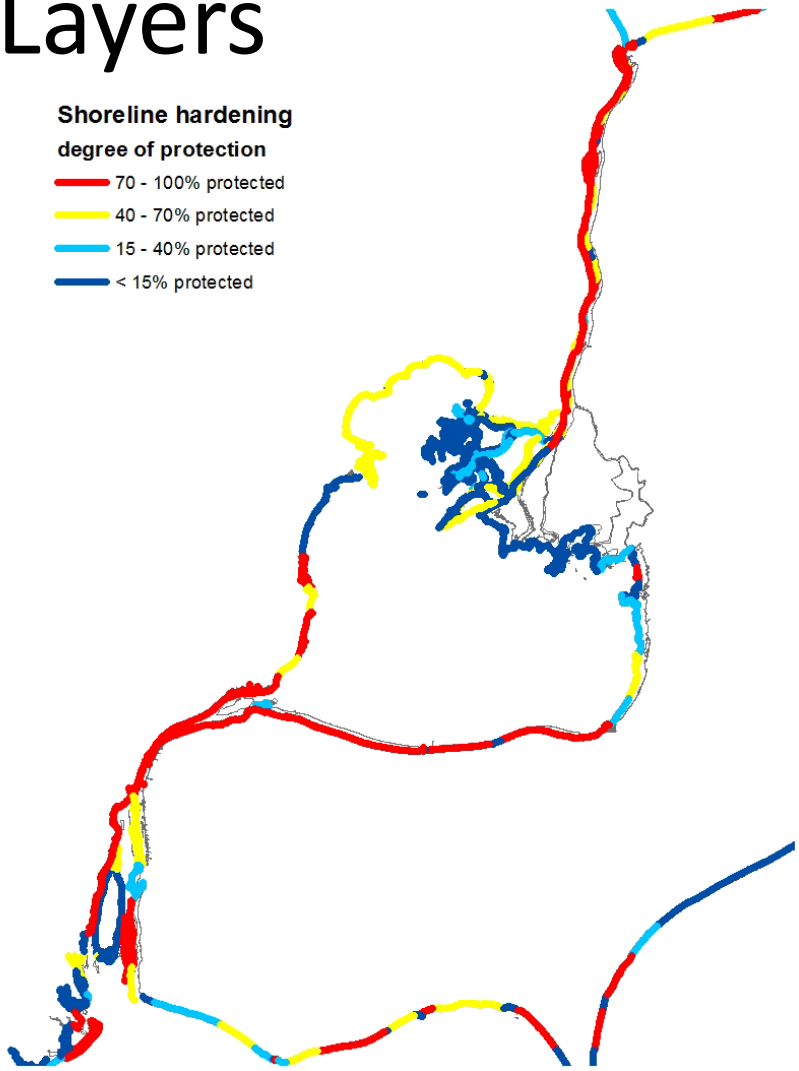
Outputs: Erie Stressor Layers

Stressors	
AOCs	Mining
Ballast Water	Mussels
Biomagnifying Metals	N loading
Boating	Native Stocking
Charter Fishing	Non-Biomagnifying Metals
Coastal development	Non-Native Stocking
Commercial Fishing	Organics
CSOs	P loading
Dams	Ports
GLEI Watershed Ag/Dev	Power Plants
HABs	Recreation
Hardening	Roads
Hypoxia	SAVs
Ice Cover	Sediment Loading
Invasive Fish	Shipping
Invasive Plants	Shoreline Extensions
Lamprey	Water Level
Light	Water Temperature



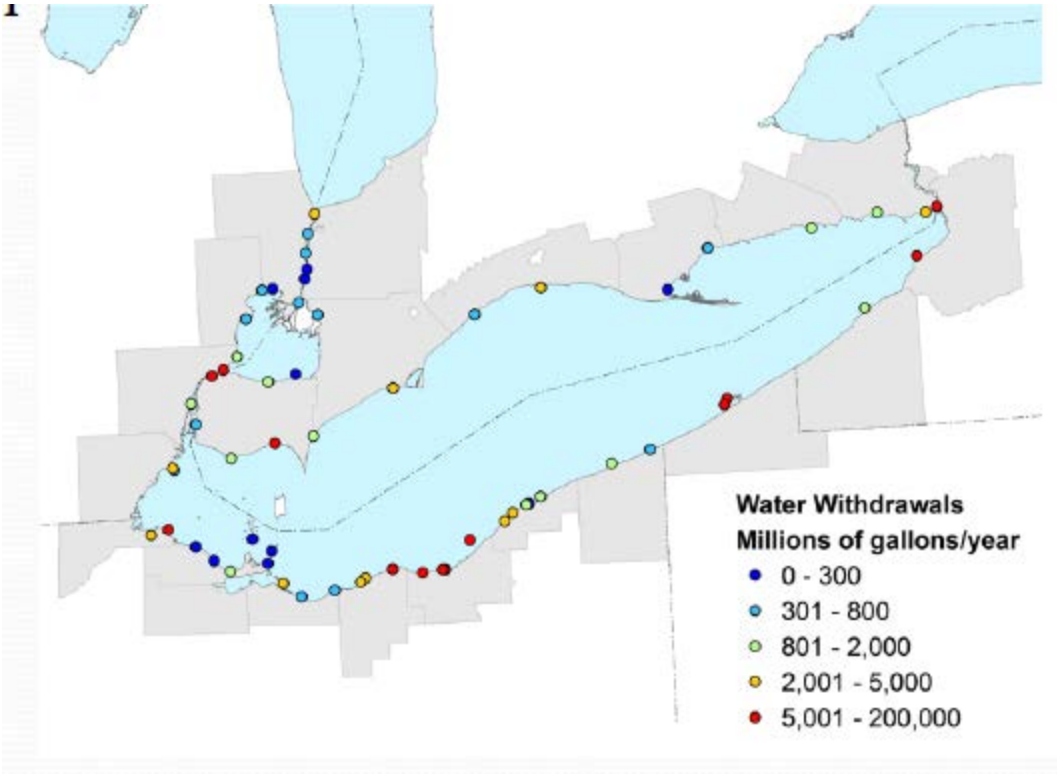
Outputs: St. Clair-Detroit River System Stressor Layers

SCDRs Layers
AOCs
Ballast Water
Charter Fishing
Coastal Development
CSOs
Dams
Industrial Ports
Light
GLEI Ag/Dev
Phoshorus Loading
Phragmites
Pipelines
Power Plants
Recreational Fishing
Round Goby
Sediment Loading
Shipping
Shoreline Hardening



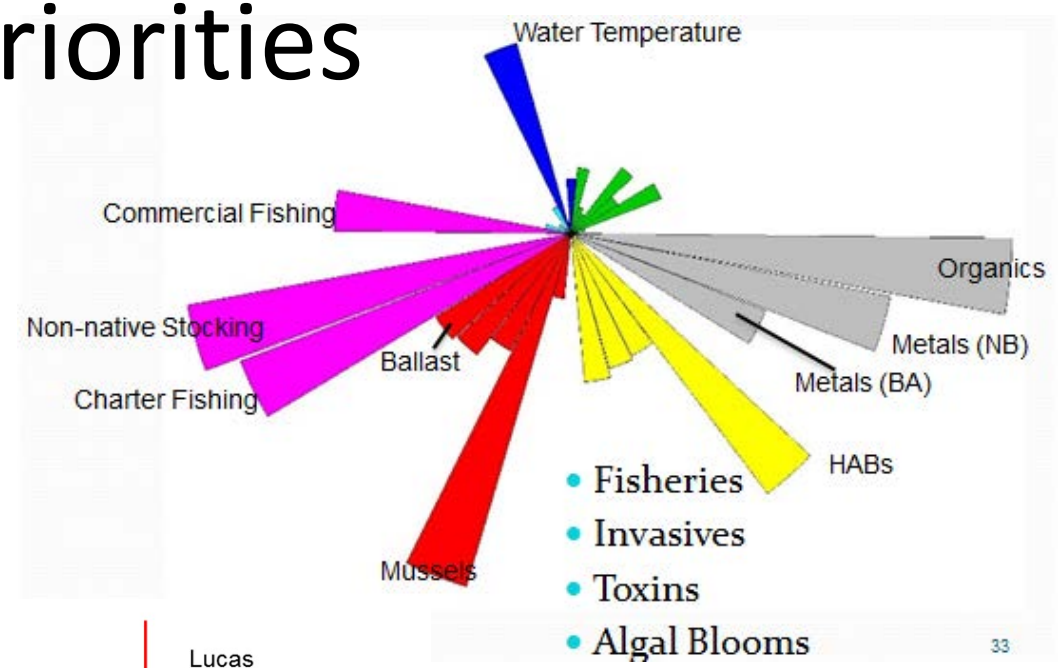
Outputs: Erie Ecosystem Services

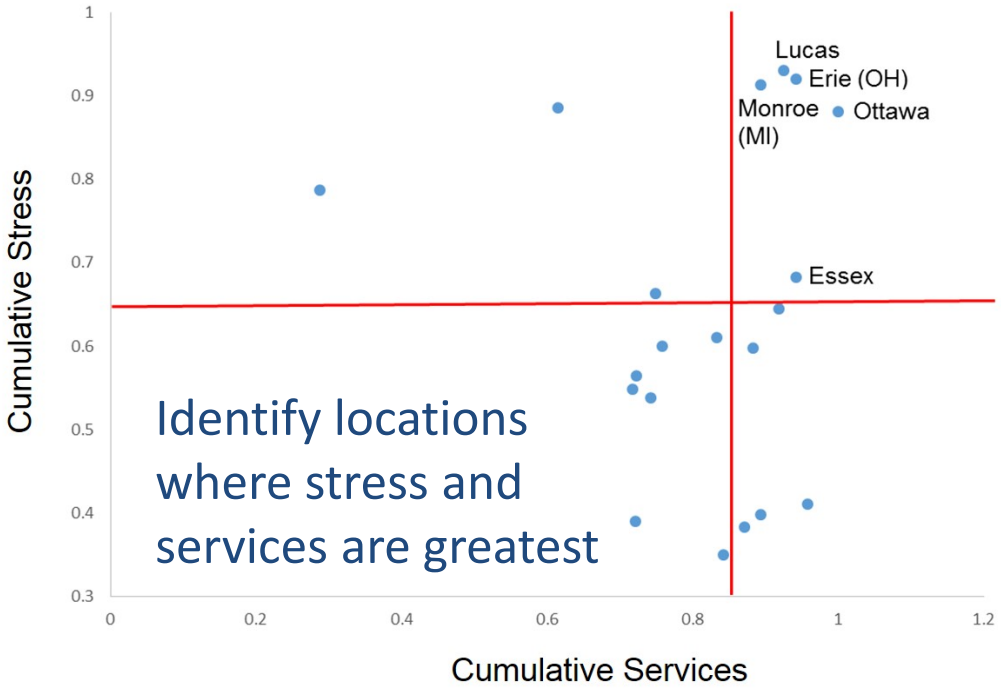
Services
Birding
Beaches
Commercial Fishing
Marinas
Parks
Sport Fishing (Charter)
Sport Fishing (Non-Charter)
TNC Coastal Terrestrial Biodiversity
TNC Coastal Wetlands Biodiversity
Water Withdrawals



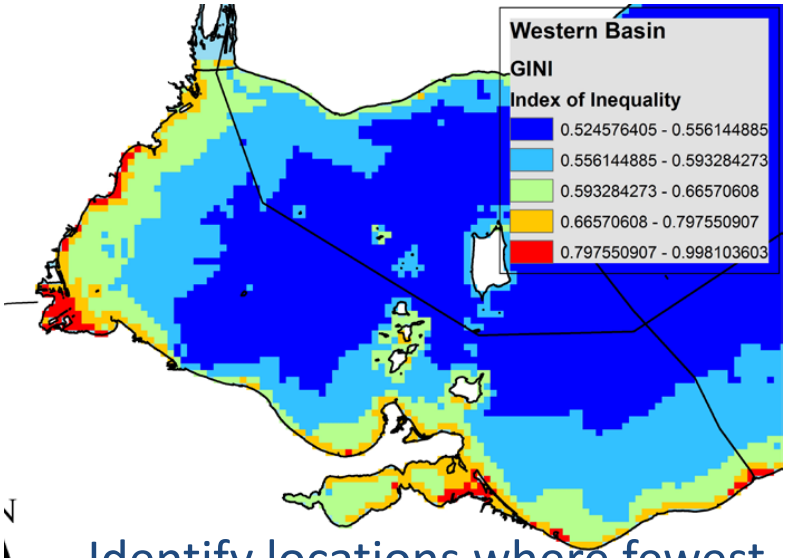
Outputs: Priorities

Identify dominant stressors by lake sub-region





Identify locations where stress and services are greatest



Identify locations where fewest stressors dominate stress

Outputs and Engagement: Management Priorities for Lake Erie

- Combine insights from analysis of multiple stressors and services, their variation across sub-regions of Lake Erie, and their spatial coincidence

- Input from experienced managers
  - Informal: feedback of steering committee
  - Formal: quantitative survey of ecosystem objectives

Priorities for Lake Erie and the Lake St Clair corridor			e Erie Subregion		Your name		
			tate or Province		Your affiliation		
Tier 1 Objectives	**Tier 2 Objectives**	**Examples**	**Importance of Objective/ES**	**Stressors**	**Importance of stressor to this objective/value**	**Reversability**	**Confidence in Evaluation**
Ecosystem Objectives	1.Healthy Fish Communities	Sport and Commercial Fishing		habitat fragmentation in watershed			
				P-loads, rivers			
				sediment loads, rivers			
				harmful algal blooms			
				hypoxia			
				cladophora			
				native fish stocking			
				non-native fish stocking			
				invasive fish (round goby)			
				sea lamprey			
				toxics and AOCs			
				commercial fishing			
				recreational/charter fishing			
				other (write-in)			
				other (write-in)			
	2.High Quality Water	Drinking Water, Beach Use		harmful algal blooms			
				hypoxia			
				nutrient loading			
				sediment			
				chemicals of mutual concern in water			
				other toxins			
				other (write-in)			
				other (write-in)			
	3.High Quality Habitat	Wetlands, Terrestrial Systems, Habitat Connectivity		invasive phragmites			
				coastal development			
				shoreline hardening			
				river mouth activity			
				other (write-in)			
				other (write-in)			
	4.Recreation/ Aesthetic Use	Beaches, Boating, Birding, Camping		harmful algal blooms			
				cladophora			
				land use in watershed			
				P-loads, rivers			
				sediment loads, rivers			
				water levels			
				litter/plastics			
				other (write-in)			
				other (write-in)			
	5.Economic/ Industrial Uses (Shipping, Power Plants)	Transportation, Energy Economies		water levels			
				inavsive species fouling			
				other (write-in)			
				other (write-in)			

Survey goals:

1. Prioritization of objectives (~parallel GLWQA objectives)
2. Identification of stressors that compromise objectives
3. Estimation of reversibility of stressors
4. Evaluator confidence self-score

Priorities for Lake Erie and the Lake St Clair corridor		e Erie Subregion		Your name	
		tate or Province		Your affiliation	

Tier 1 Objectives	Tier 2 Objectives	Examples	Importance of Objective/ES	Stressors	Importance of stressor to this objective/value	Reversability	Confidence in Evaluation
Threat Abatement Objectives	6. Reduction of Excess Nutrients	HABs, Hypoxia, Beach Fouling, WQ Degredation		harmful algal blooms			
				cladophora			
				land use in watershed			
				P-loads, rivers			
				sediment loads, rivers			
				other (write-in)			
				other (write-in)			
	7. Prevention/ Control of Invasive Species	Biodiversity, Fouling, Food Web Integrity		sea lamprey			
				round goby			
				dreissenid mussels			
				invasive phragmities/other macrophytes			
				asian carp			
				alewives			
				recreational boating (transfer of AIS)			
				shipping (ballast)			
				other (write-in)			
				other (write-in)			
	8. Prevention/Reduction in Toxic Chemicals/ Delistment of AOCs	Public Health, Fish Consumption, Ecosystem Health		AOCs			
				PCBs			
				copper			
				mercury			
				chemicals of mutual concern in water			
				PBTs			
				discharges from vessels			
				other (write-in)			
				other (write-in)			
	9. Improved Groundwater Condition	Drinking Water, Public Health, Ecosystem Health		land use in watershed			
				other (write-in)			
				other (write-in)			
	10. Climate Change Impacts	Shoreline Exposure/Inundation, Ecosystem Effects, Infrastructure Risk		changing water levels			
				reduced ice cover			
				land use in watershed			
				other (write-in)			
				other (write-in)			

End User Engagement

- **Collaboration**
  - TNC (Lake Erie Biodiversity Conservation Strategy), GLAHF, GLEI
  - Engaging with lake managers and scientists from NGOs, governmental and educational institutions in the stressor interactions and Lake Erie projects.
  - Participating in Lake Erie LAMP calls and meetings

- **Data sharing**
  - Secured permission from original data providers to share rescaled GLEAM1 layers with other research groups
  - Filled 13 requests in past year for GLEAM data layers (Great Lakes Futures Project, USGS, TNC, University of Minnesota, and students at UM, University of Guelph and University of Waterloo).

- **Education and outreach**
  - Filled 6 requests for information in past year from students, nonprofits, government agencies, and concerned citizens
  - Website improvements (ongoing; fixing issues with interactive map, updating Drupal, adding content)

With the help of many!

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  - S.D.P. Smith, P. McIntyre, C. Joseph, C. Dickinson, A. Marino, R. G. Biel, J. Olson, P. Doran, E. Rutherford
- Data providers
  - Dozens of staff from GLERL, USGS, Environment Canada, OMNR, USFWS, TNC, GLFC, MDNRE, IFR, GLEI, NFHAP, others.
  - Academic scientists from USA & Canada

http://www.greatlakesmapping.org