The Economic Impacts of Harmful Algal Blooms

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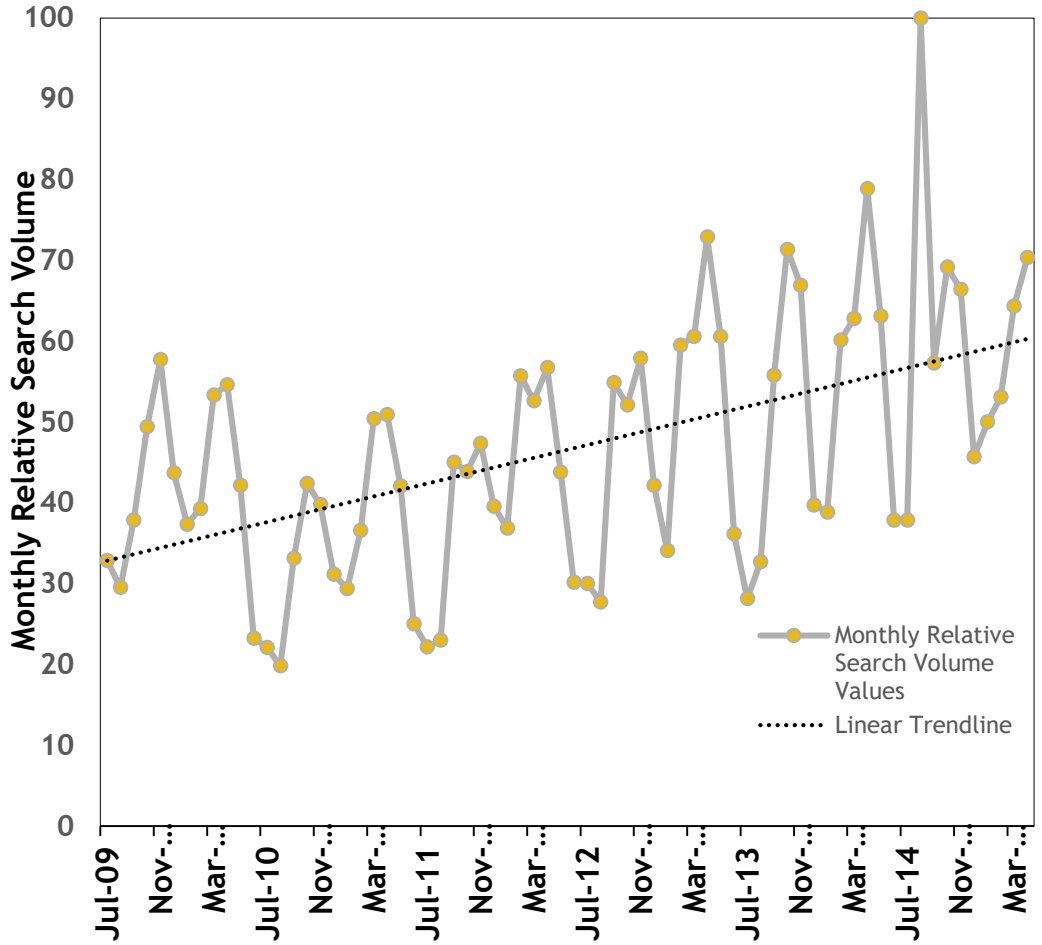
My Research

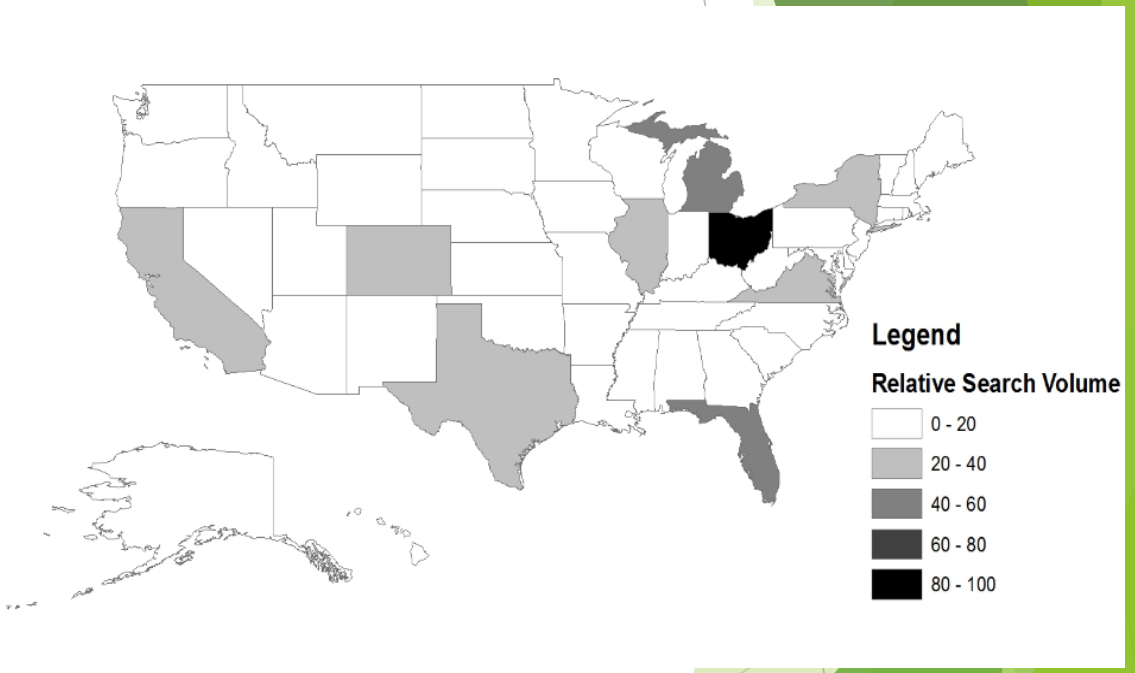
- I am an environmental economist developing novel methods to link the environment to the behavior of people
- I use linkages between the environment and human behavior to answer:
  - What is the impact of the environment on people's decisions?
  - How do people value the environment?
  - What is the role of policy in altering people's well-being and the environment?
- To answer these questions, I use information from markets and the decisions people make in those markets to learn about the environment

Overview of HAB Research

- Do HABs impact behavior?
  - Evidence of Awareness
- Anglers and fishing licenses
- Inland Ohio lakes and housing market implications
- Ongoing research
  - Lake Erie housing markets
  - Impacts on Erie recreation

HABs: A Growing Concern (via Google)

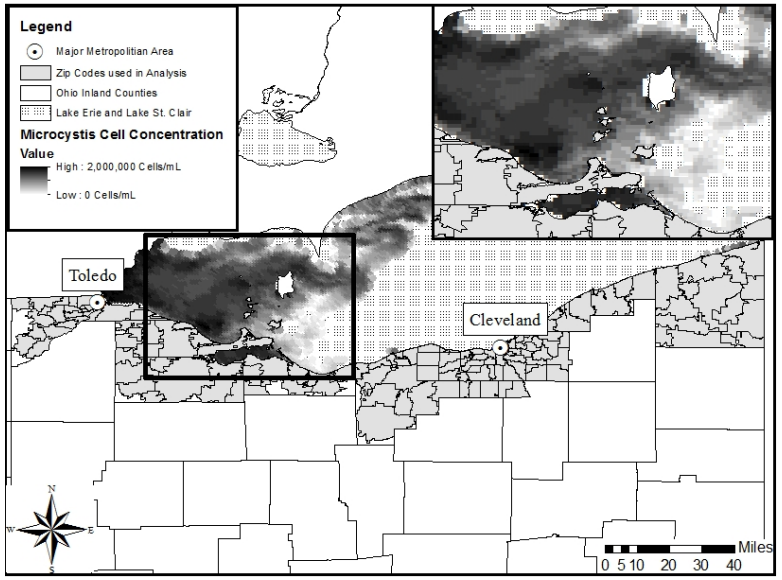




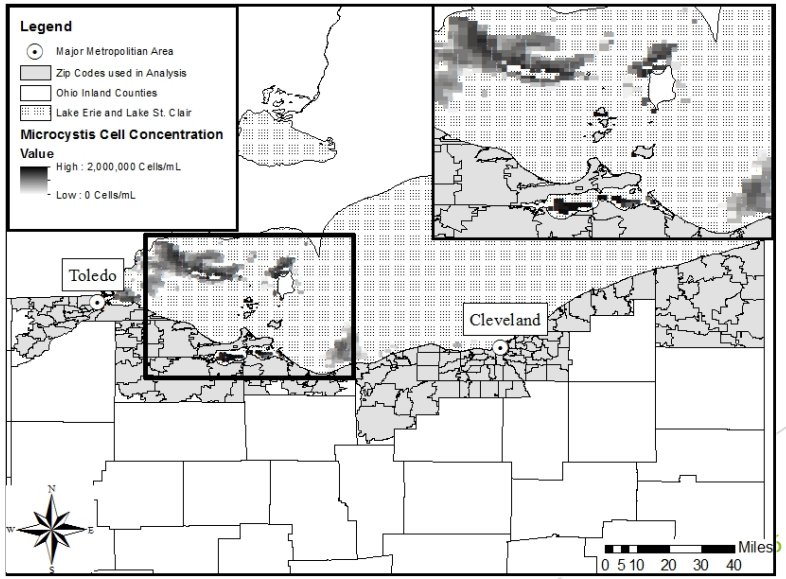
HABs and Ohio Anglers

HABs and Anglers

- What is the impact of exceeding Ohio EPA recreation advisory levels on annual fishing permit sales?
  - Data: 2009 to 2014
  - All Ohio annual fishing license sales
- How far from Lake Erie do changes in license sales occur?
- Extrapolate changes in license sales to recover losses in fishing related revenue to local communities



September 2011



September 2012

HABs and Anglers

- Fishing license sales drop between 10% and 15% when algal conditions are elevated
- Decreases in license sales appear limited to communities within 20 km of Lake Erie
- A large, summer-long bloom would result in approximately 3,600 fewer annual fishing licenses issued

Variables	<10km	10km - 20 km	>20km
Moderate Threshold (0/1)	-0.156***	-0.105**	0.0410
	(0.0351)	(0.0407)	(0.0411)
Water Temperature (Degrees Celsius)	0.0307***	0.0311***	0.0158
	(0.0113)	(0.0109)	(0.0183)
Heavy Rain	-0.0537***	-0.0474***	-0.0745***
	(0.0144)	(0.00924)	(0.0145)
Heavy Rain Squared	0.00211***	0.00198***	0.00307***
	(0.000620)	(0.000430)	(0.000574)
Constant	-0.111	-3.470***	-2.026***
	(0.160)	(0.171)	(0.305)
Observations	3,807	1,692	1,363
Month By Year Fixed Effects	Yes (46)	Yes (46)	Yes (46)
ZipCode Fixed Effects	Yes (80)	Yes (35)	Yes (28)

Notes: ***, **, * indicates significance at the 1%, 5% and 10% level respectively. Standard errors have been clustered at the zipcode level. All columns use a negative binomial functional form.

Policy Implications: Impacts on Local Communities

- Sohngen et al (2015) estimate 17.6 annual trips to Lake Erie per angler with an expenditure of $88 per trip
- The loss of 3,600 anglers would result in at least a loss of $5.6 Million in local revenue
- This number is not a full accounting of harm to local anglers as many may still fish but in less desirable locations/further from home

- For more details, see:

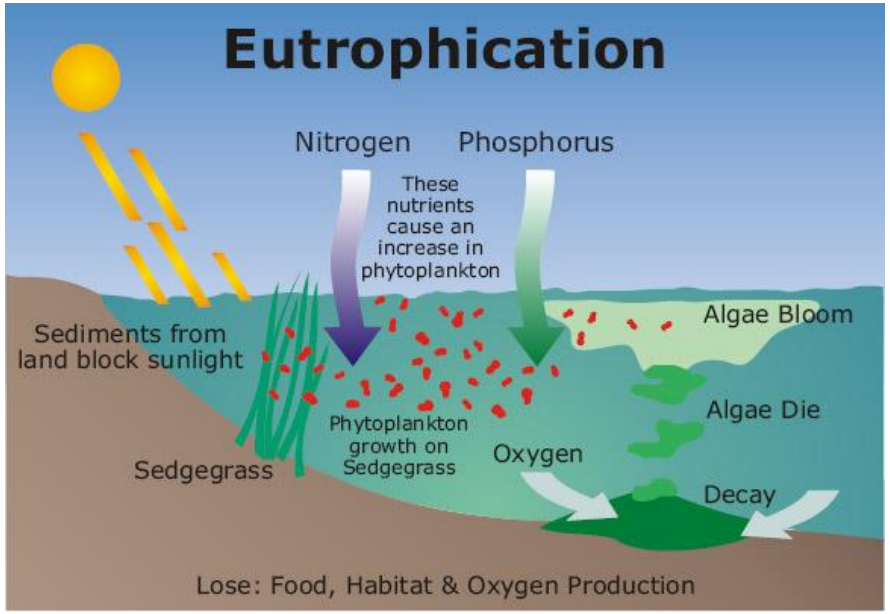
Wolf, D, Georgic, W and Klaiber, HA. “Reeling in the Damages: Harmful Algal Blooms’ Impact on Lake Erie's Recreational Fishing Industry.” Journal of Environmental Management. Vol. 199: 148-157. 2017.

HABs and Inland Ohio Lakes

Inland Lakes – Impacts on Local Populations

Excessive blue-green (BG) algae concentration levels can lead to environmental and economic problems

Toledo Water Crisis (Aug. 2014)



Lake Eutrophication

Policy Responses and Costs of Management

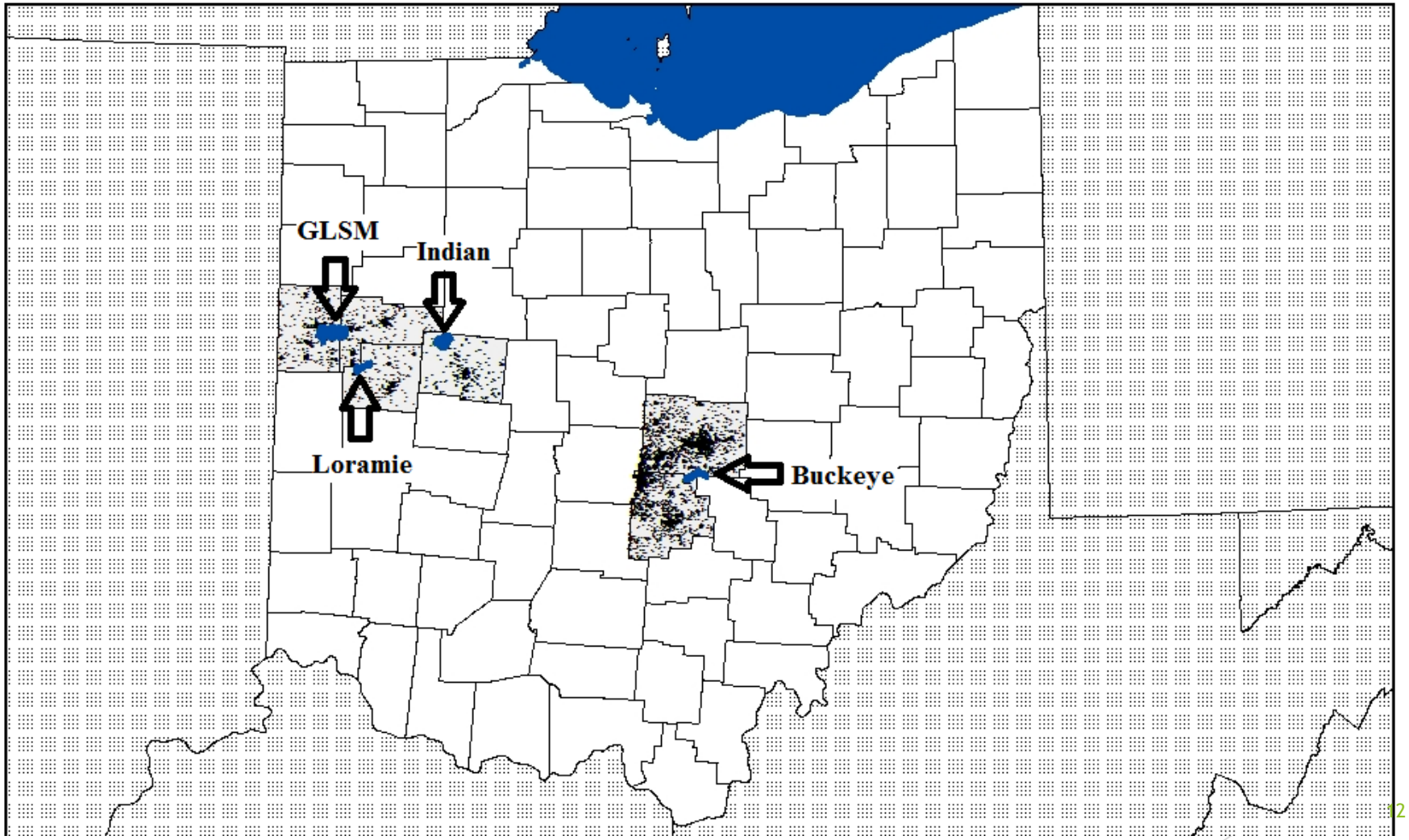
Ohio EPA – Early Action

- 2007 - National Lake Survey
- 2008 - Initiation of new Ohio EPA Inland Lakes Monitoring Program
- 2008 - Formation of a Harmful Algal Bloom Workgroup and Initiative
- 2009 - Microcystin results from National Lake Survey released.
- 2012 – Second National Lake Survey

Government Expenditure

- Great Lakes Restoration Initiative: $300 million annual budget
- Ohio EPA: $26 million spent on Grand Lake Saint Mary's cleanup
- City of Toledo: $4.7 million annual water treatment costs

Study Area (Housing sales 2009 – 2015)

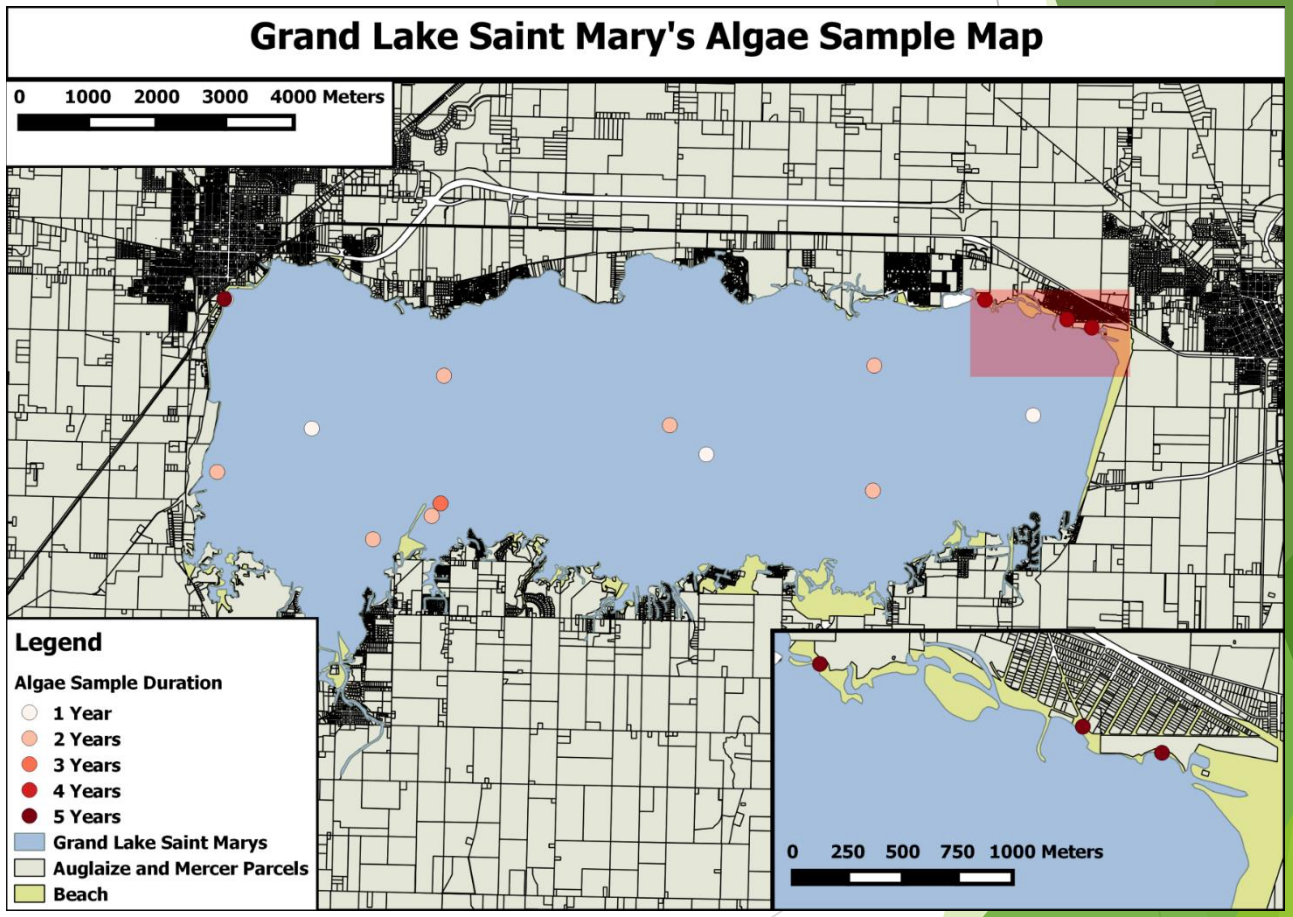


Hedonic Model – Resident Awareness

- What is the impact of HABs on nearby home values in Ohio's inland lakes?
- How do these values change across space?
  - As one moves further from the lake
  - Between Buckeye lake and other lakes in Ohio
- To answer these questions, we combine data on housing sales with information about HAB conditions at the time of sale using a "hedonic model"
  - Link environmental conditions to the sale prices of homes
  - Control for a wide range of structural differences between homes and neighborhood attributes (e.g. school quality, crime, etc) to isolate the impact of environmental conditions on housing value

Housing Transactions

- 16,589 transactions in study area
  - 12K from Buckeye Lake area
- Data covers the period 2009 through 2015
- Assembled from county auditors in 6 Ohio counties
  - Mostly ex-urban/rural areas and does not include large metro centers
- The “West Market” average sale price was $131K compared to $154K for the “East/Buckeye Market”



Findings – Markets Respond to HABs

- Homes closest to the lake experience the largest property price impacts
- There are differences across Buckeye and other inland lakes, although these diminish for non-adjacent near-lake homes
- Spatial extent of impacts is fairly limited, within 500 meters

Variable	(1) Buckeye	(2) West
LakeAdj*Algae	-0.224***	-0.403***
	(0.0569)	(0.116)
Lake250*Algae	-0.175***	-0.143*
	(0.0303)	(0.0790)
Lake500*Algae	-0.0377	0.0604
	(0.0677)	(0.106)
LakeAdj	0.900***	0.736***
	(0.0767)	(0.0792)
Lake250	0.431***	0.115
	(0.0378)	(0.0995)
Lake500	0.0686	-0.131
	(0.0591)	(0.0857)
Tract FE	63	41
Year FE	6	6
Monthly FE	11	11
Observations	12169	4420
R-squared	0.712	0.718

*Selected Results. Interpret as % of sales price

HABs and Housing Values

- During a HAB outbreak, near lake home values drop between 11%- 17%, on average
- Property losses for recurrent algal blooms in Grand Lake St Marys could exceed $51 million
  - Losses increase to over 22% for lake adjacent homes
  - Persistent HABs on Buckeye and GLSM could cost upwards of $150 million in property losses

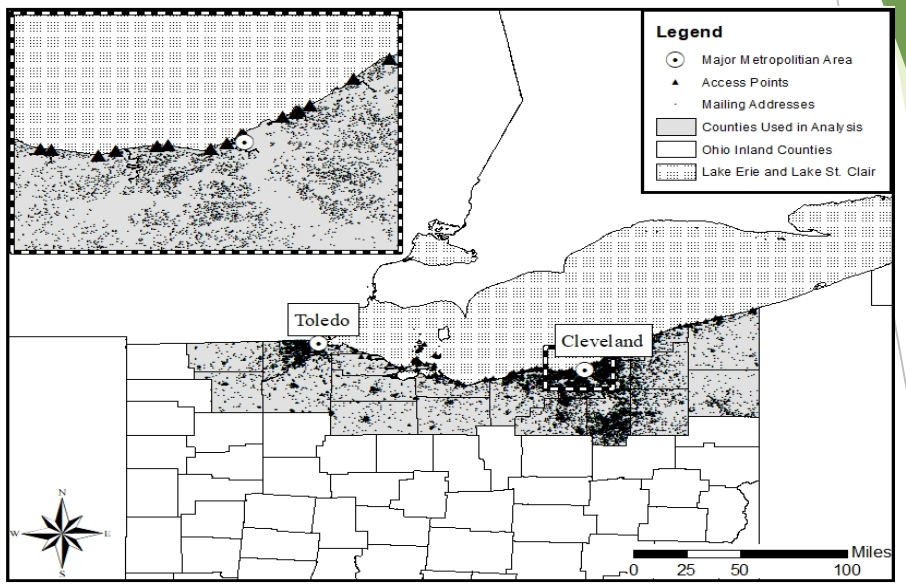
- For more information, see:

  Wolf, D and Klaiber, HA. "Bloom and Bust: Toxic Algae's Impact on Nearby Property Values." Ecological Economics. Vol. 135: 209-221. 2017.

Ongoing Research: HABs and Erie

HABs and Recreators (ongoing work)

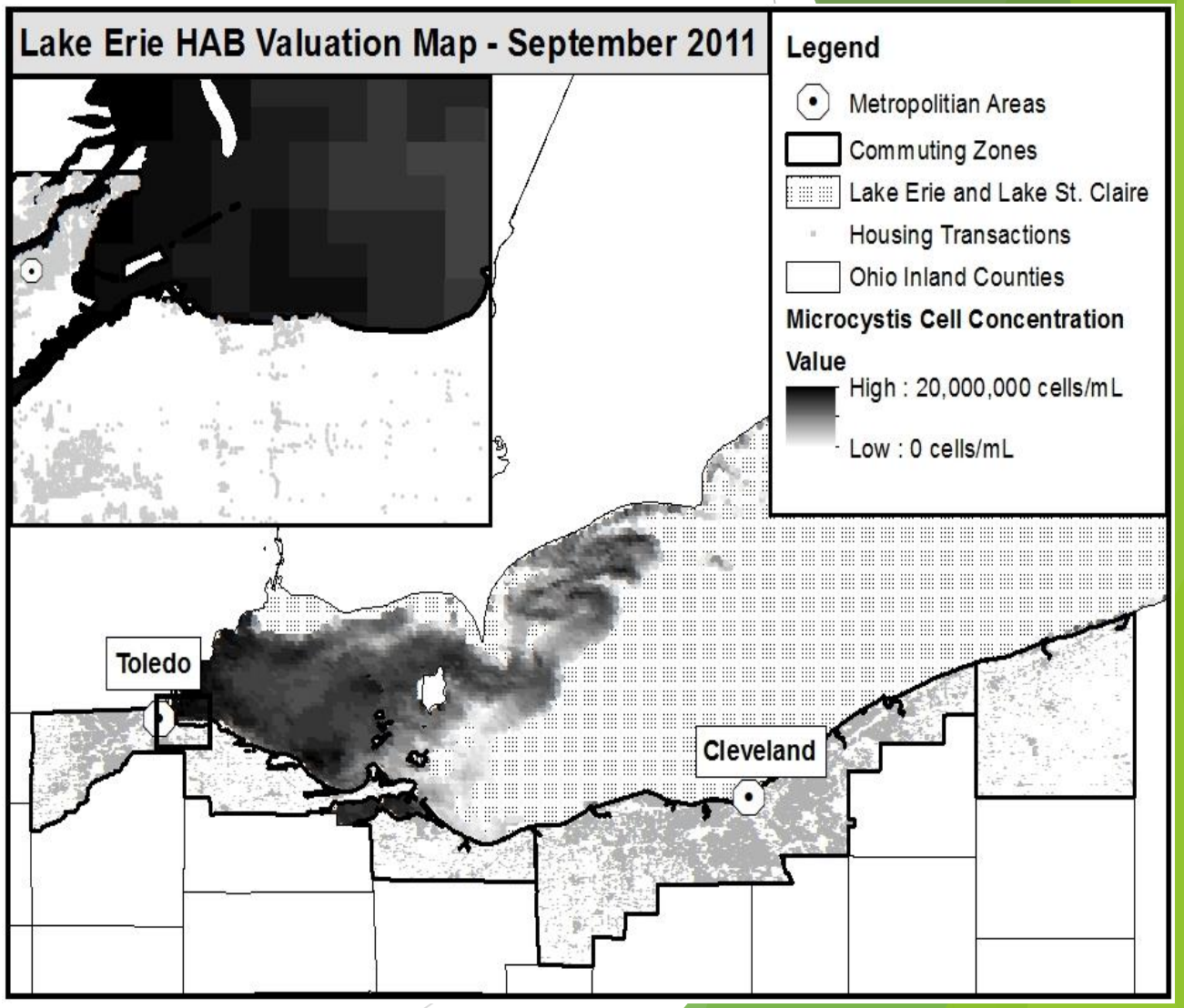
- Mailed survey to 20,000 Ohio Residents in 2017
  - Asked where they recreated in summer of 2016 from 104 potential access points
- Willingness to pay to avoid algae differed depending on type of recreation
  - Swimmers most impacted by E. Coli
  - Boaters/Anglers most impacted by Algae
- The presence of HABS in Lake Erie's western basin reduce recreator well-being by $19.8-$29.1 million annually
  - Does not account for additional losses to nearby communities from recreation related expenditure



Chen, W, Wolf, D, Gopalakrishnan, SG, Haab, T, Klaiber, HA. "The Impact of Algae on Recreation Behavior."

Housing Values along Lake Erie

- Data on housing 2002-2014 from 7 Ohio county auditor offices
- Linked to NOAA satellite-imagery on algae
- Find substantial differences in impacts of water quality along the Erie shoreline
  - Losses similar to those in inland lakes study
  - Communities with lower ambient algae levels, have higher Willingness To Pay for algae prevention than communities with consistently poor water quality
- Estimate future damages using HAB forecasting model (Stumpf et al. 2012) and climate scenarios (Johnson et al. 2015)



Wolf, D, Gopalakrishnan, SG, Klaiber, HA. "The Cost of Algae Contamination in Freshwater Lakes: Identification of Demand Functions for Environmental Quality."

Thank you!

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