Distribution of Cyanobacteria and Microcystin in Lakes of the US Driven by Combination of Lake, Watershed, and Climate Characteristics


US EPA


European Space Agency

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Oregon Cyanobacterial Harmful Algae Bloom Meeting

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Office of Research and Development
Center for Public Health and Environmental Assessment

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Motivation

Develop models to assess the risk of toxic cyanoHABs among lakes in the conterminous United States

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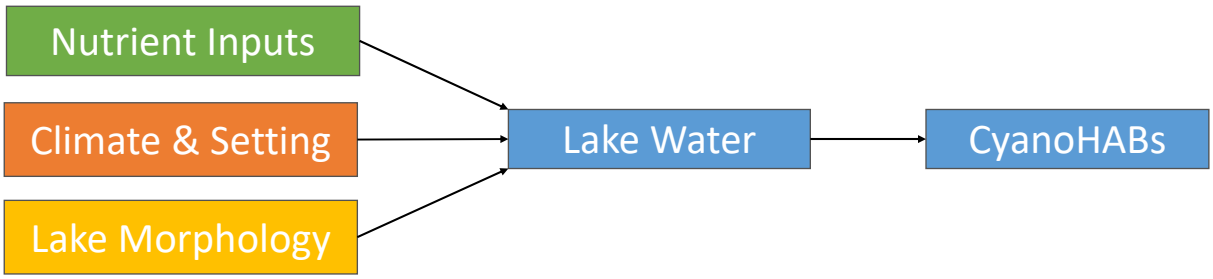
Conceptual Framework



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Covariates Considered

Lake Water	Nutrient Inputs	Climate & Setting	Lake Morphology
• Water chemistry • Water physical properties • Evaporation • Inflow	• Land cover • Nutrient inventory	• Temperature • Precipitation • Ecoregion • Baseflow	• Depth • Fetch
National Lakes Assessments	**LakeCat**		**National Hydrography Dataset**

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Approach

Cyanobacteria abundance (cells/ml)
or
Microcystin detection (0.1 ug/L)

R Package spmodel

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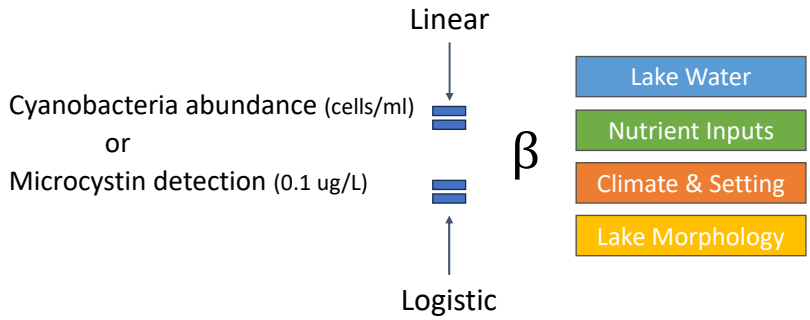
Approach



R Package spmodel

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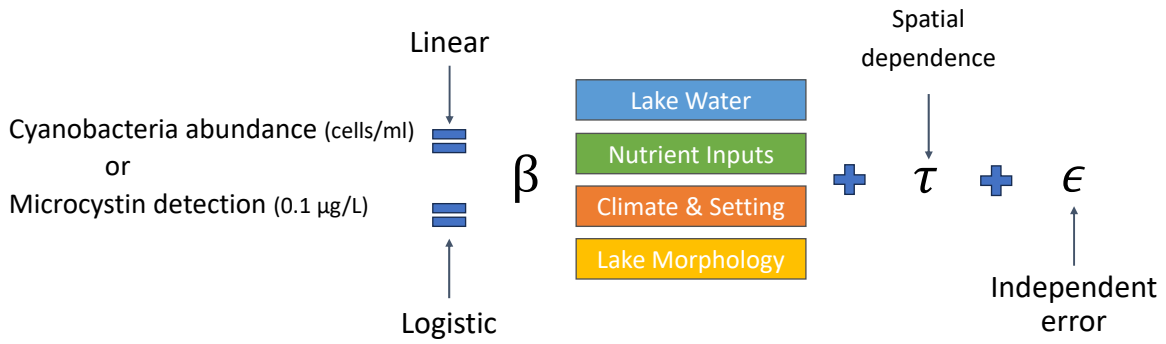
Approach



R Package spmodel

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Cyanobacteria Abundance

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Cyanobacteria Abundance - Covariates

Covariate	Direction	P-value
Total Nitrogen	+	<0.001
Nitrate Concentration	–	<0.001
Ammonia concentration	–	<0.01
pH	+	<0.001
Evaporation	+	<0.01
Dissolved Organic Carbon	–	<0.001
Agricultural cover	+	<0.001
Precipitation (30 yr mean)	–	<0.1
Temperature (30 yr mean)	+	<0.001
Ecoregion – Western US	–	<0.001
Lake depth	–	<0.1

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Precipitation (30 yr mean)	–	<0.1
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Lake depth	–	<0.1

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Cyanobacteria Abundance - Covariates

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	Nitrate concentration	–	<0.001
	Ammonia concentration	–	<0.01
	pH	+	<0.001
	Evaporation	+	<0.01
	Dissolved organic carbon	–	<0.001
Nutrient Inputs	Agricultural cover	+	<0.001
Climate & Setting	Precipitation (30 yr mean)	–	<0.1
	Temperature (30 yr mean)	+	<0.001
	Ecoregion – Western US	–	<0.001
Lake Morphology	Lake depth	–	<0.1

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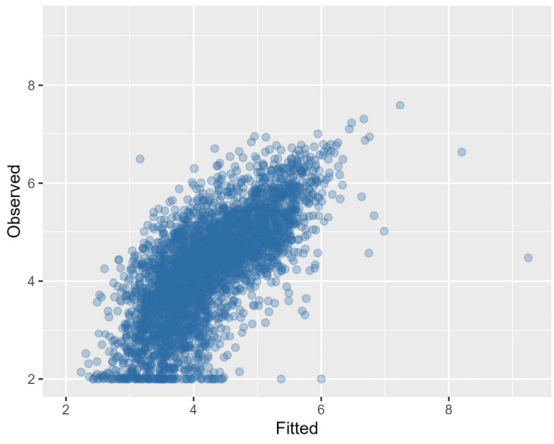
Cyanobacteria Abundance - Fit

Log10(Cyanobacteria + 100)

Spatial $R^2 = 0.48$

Non-spatial $R^2 = 0.42$



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Microcystin Detection

Probability of exceeding 0.1 µg/L

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Microcystin Detection - Covariates

	Covariate	Direction	P-value
Lake Water	Total Nitrogen	+	<0.001
	Nitrate	–	<0.001
	pH	+	<0.001
	Evaporation/Inflow	+	<0.05
Nutrient Inputs	Agricultural cover	+	<0.001
	Developed cover	+	<0.01
Climate & Setting	Temperature (month mean)	-	-
	Ecoregion – Western Mtn	–	<0.001
	Baseflow index	–	<0.05
Lake Morphology	Lake depth	–	<0.01
	Fetch	+	<0.01

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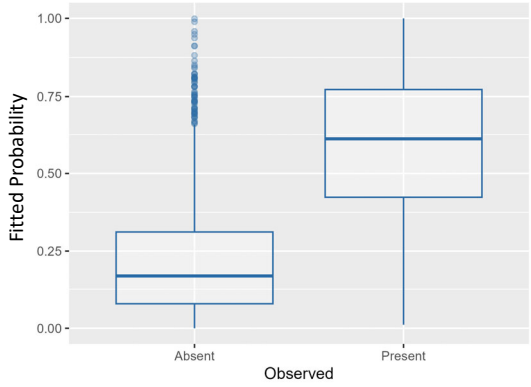
Microcystin Detection - Fit

Spatial AUC = 0.90

Non-Spatial AUC = 0.83



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Insights – Cyanobacteria & Microcystin

Similarities

- In-lake conditions represent bloom conditions
- Land cover as longer-term nutrient status
- Shallow lakes with higher evaporation more vulnerable
- Western lakes have lower response

Differences

- Climate relevant to cyanobacteria but not microcystin
- More spatial correlation in microcystin error than cyanobacteria
- DOC negatively related to cyanobacteria

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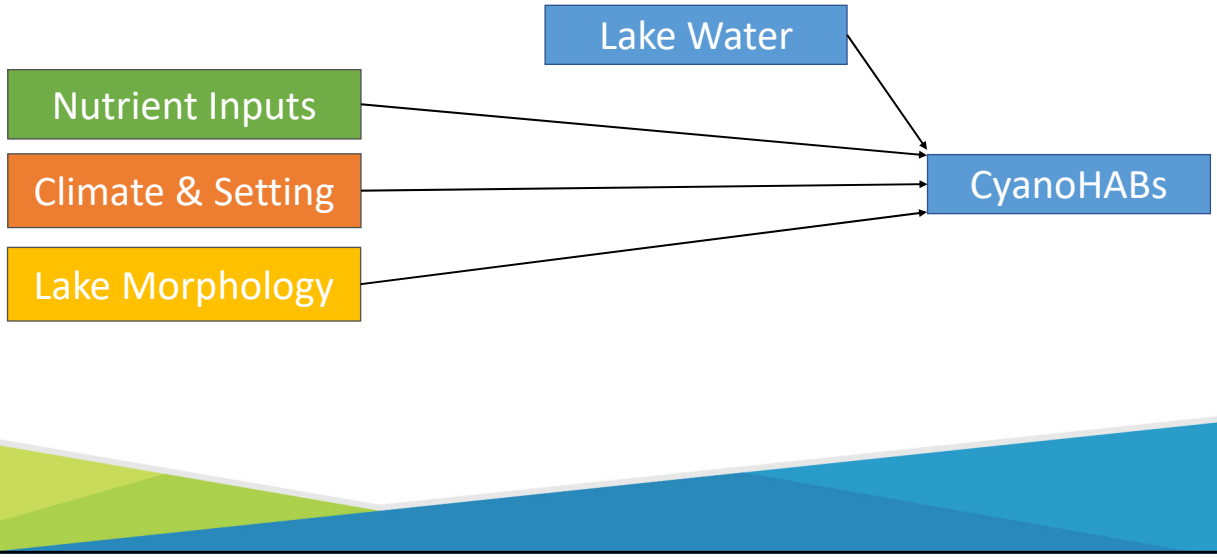
Next Steps



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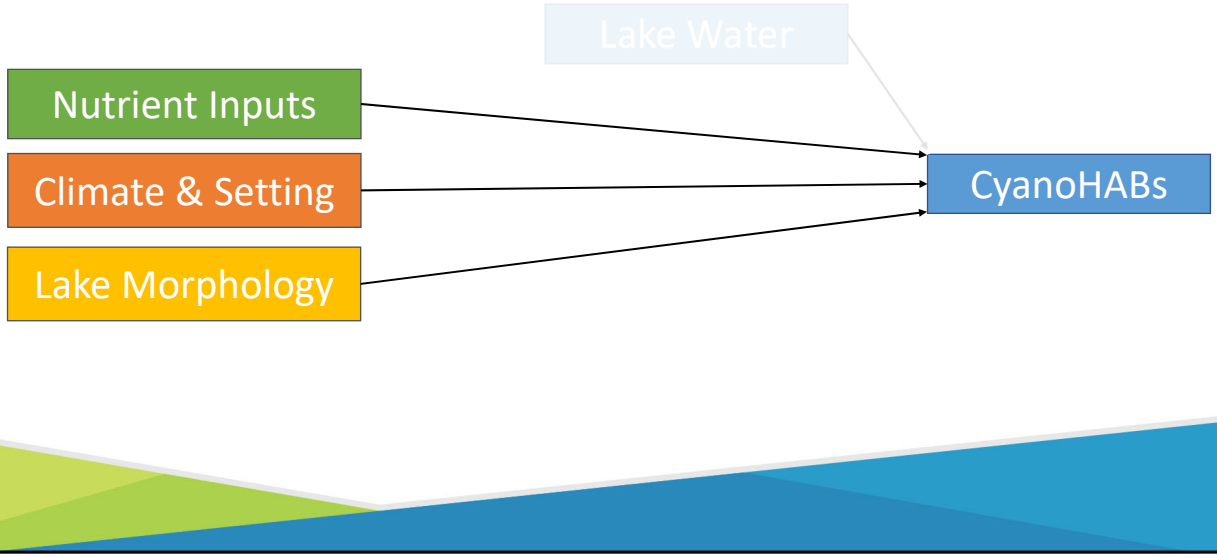
Next Steps – Remove In-Lake Data



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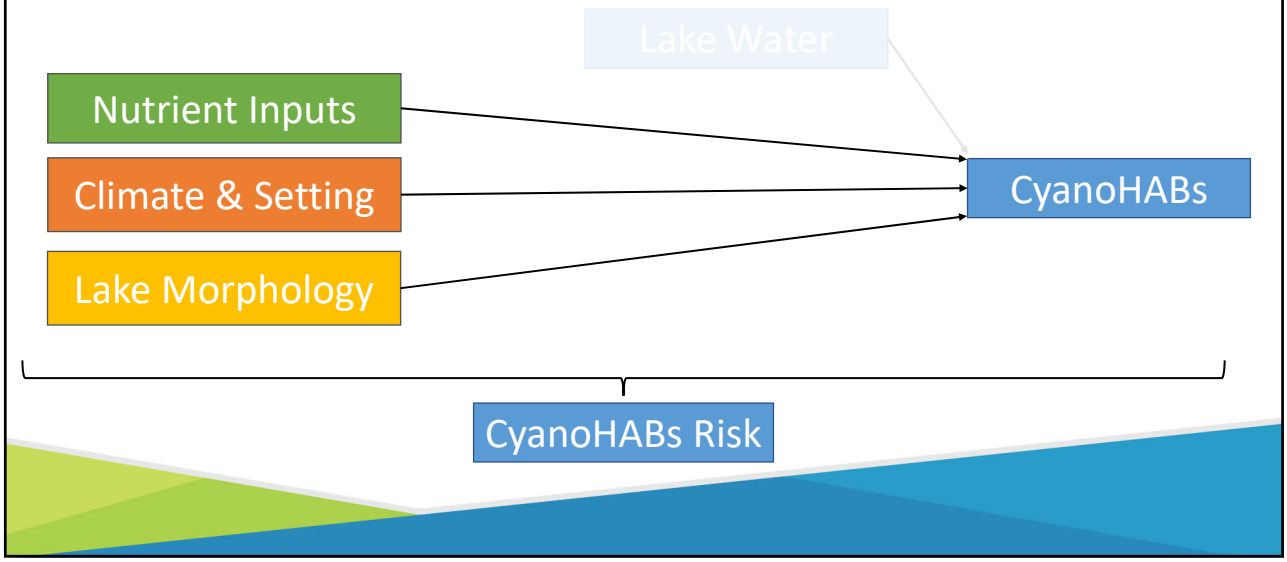
Next Steps – Apply to New Lakes



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EPA

Thank You!
Questions?

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Extra Slides

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National Lakes Assessment (NLA)

Surveys: 2007, 2012, and 2017

Lakes: ~2,500

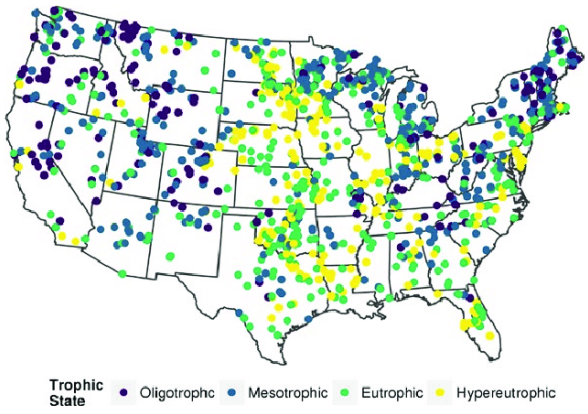
Observations: ~3,700

Single sample in Jun-Sep

Lake size: 0.4 – 16k km^2

CyanoHAB metrics

- Microcystin
- Cyanobacteria abundance



Hollister et al. (2016) *Ecosphere*

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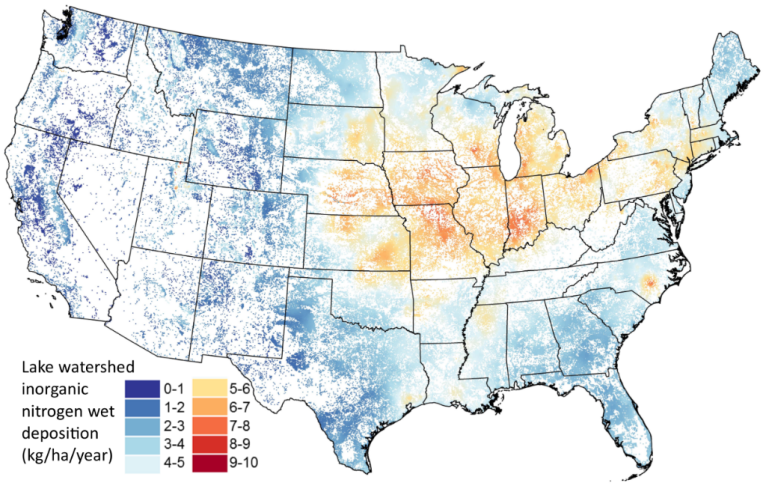
About LakeCat

- Geospatial framework for lake watershed data
- ~380,000 lakes
- Metrics include
  - Climate
  - Land cover/land use
  - Topographic setting
- Can add data using the framework



https://www.epa.gov/national-aquatic-resource-surveys/lakecat-dataset-0

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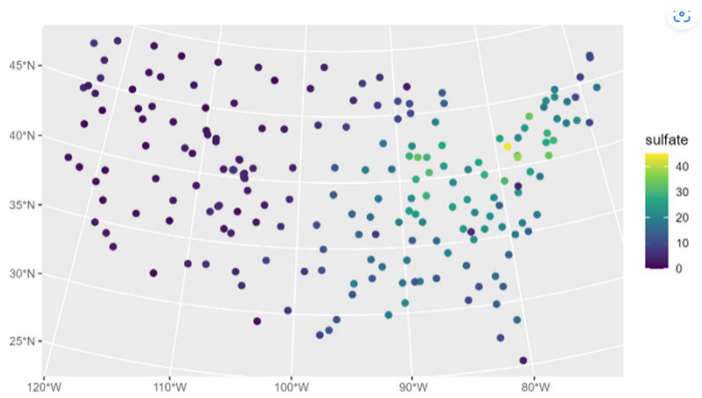
Spatial Modeling Framework

Observations may be correlated in space

R Package spmodel



Dumelle et al. (2023) *PLOS ONE*

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