

Spatial Heterogeneity in Hedonic Price Effects for Lake Water Quality

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Motivation

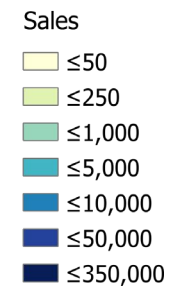
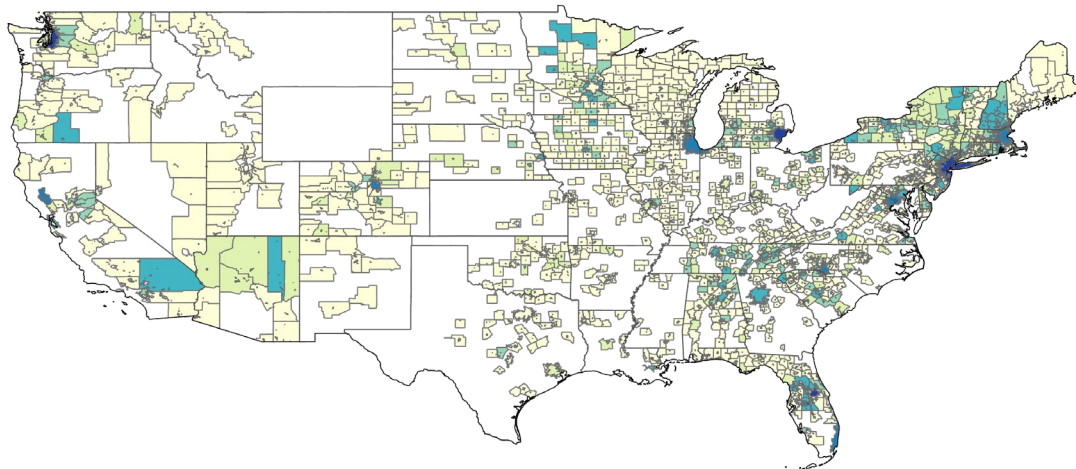
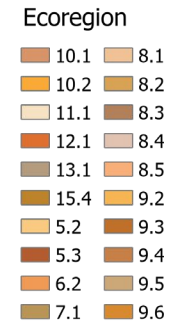
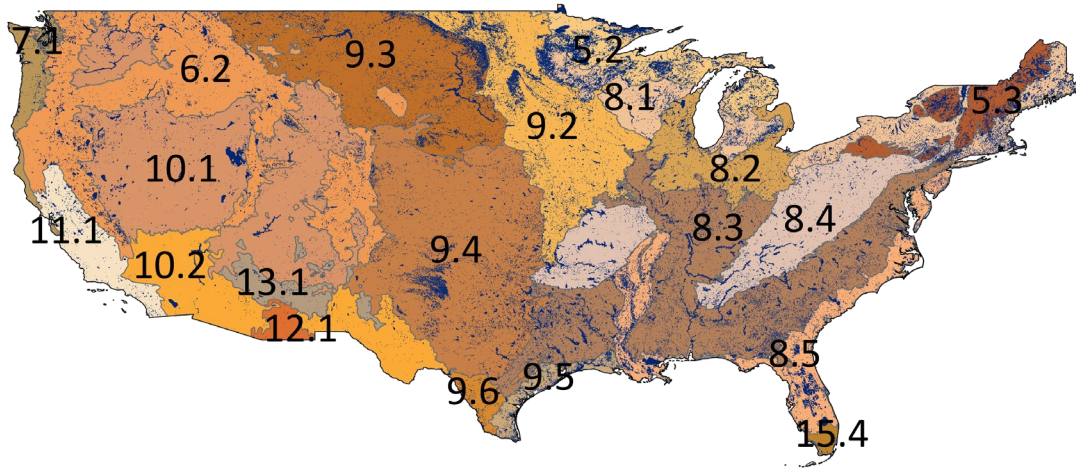
- Strong interest in evaluating the effects of lake water quality on housing markets nationally
 - Moore et al. (2020), Zhang et al. (2022)
- But ecological conditions on lakes vary across the country and can shape local policy outcomes
 - Baseline levels of water quality matters
- Homeowner preferences for water quality vary as well
 - Foot test for swimming depends on baseline
 - Wolf and Kemp (2021), Zhang et al. (2022)
- Some variation can be captured through meta-analysis (Guignet et al., 2022)
 - Local studies in the meta-data miss out on large parts of the country with limited data
- Defining market boundaries at larger spatial scales incorporates previously unstudied areas
 - But what are the appropriate market boundaries for environmental amenities?

Research Questions

1. How do the effects of lake water quality on property sales vary across the United States?
2. Do market boundaries and the spatial scale of the hedonic model impact estimates?
3. Are estimates sensitive to other types of investigator decisions?

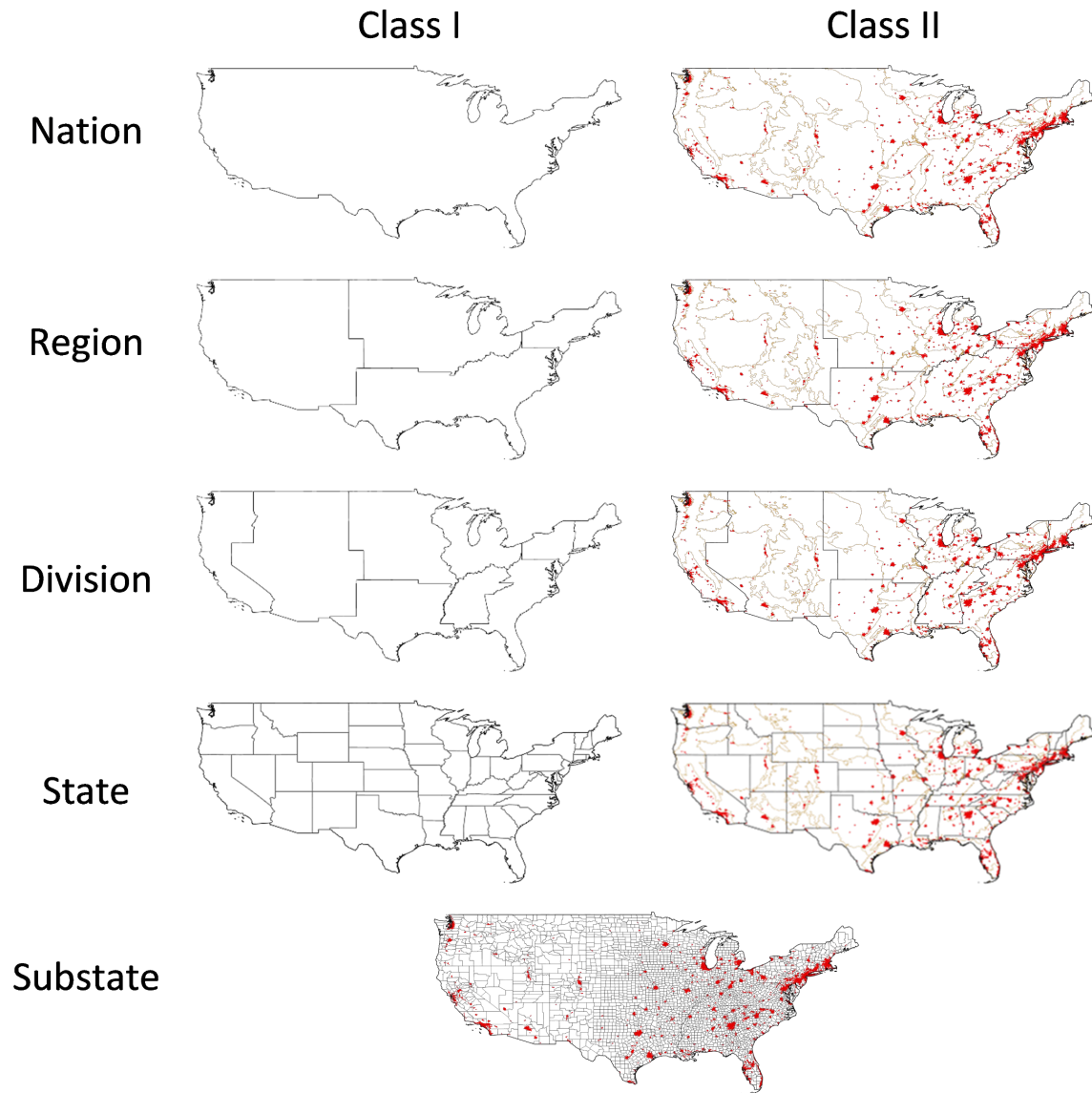
Key Findings

- Lake water quality elasticities are heterogeneous across political and ecological regions
- Market boundary definitions and spatial scale play a large role in hedonic estimates
- Sensitivity of hedonic estimates varies across regions



Data

- NHD Lakes over 4ha
- Water quality
 - Secchi depth and chl-a
 - From LAGOS-NE and WQP
- Boundaries
 - EPA level II ecoregions
 - 2010 Census counties and urbanized areas
- PLACES curated data
 - ZTRAX property sales (2000-2021)
 - Matched with parcel data, distance to lake, NHGIS, and USGS data
 - Filter for high and medium confidence sales



Political Boundary
 ■ Urbanized Areas
 Ecoregions

Market Boundaries

- 5 different spatial scales
 - Defined by political boundaries
 - Substate boundaries consist of urbanized areas and counties
- 2 types of market boundary classes
 - I: Political boundaries only
 - II: Political boundaries and ecoregions
- Substate boundaries are a combination of both types of boundary classes

Model Equations

- Modelling heterogenous effects for class II market boundaries

$$\ln(P_{it}) = \beta_0 + \beta_1 \ln(WQ_{it}) + \beta_2 \ln(WQ_{it}) * LF_i + \beta_3 \ln(WQ_{it}) * \ln(Dist_i) + \beta_4 \ln(WQ_{it}) * \ln(Area_i) \\ + \beta_{Prop} Prop_i + \beta_{Control} Control_i + \gamma_t + \tau_{it} + \epsilon_{it}$$

- Modelling additional spatial heterogeneity for class I market boundaries

$$\ln(P_{it}) = \beta_0 + \beta_1 \ln(WQ_{it}) + \beta_2 \ln(WQ_{it}) * LF_i + \beta_3 \ln(WQ_{it}) * \ln(Dist_i) + \beta_4 \ln(WQ_{it}) * \ln(Area_i) \\ + \beta_5 \ln(WQ_{it}) * U_i + \beta_E \ln(WQ_{it}) * E_i + \beta_S \ln(WQ_{it}) * S_i \\ + \beta_{Prop} Prop_i + \beta_{Control} Control_i + \gamma_t + \tau_{it} + \epsilon_{it}$$

- Computing elasticity estimates

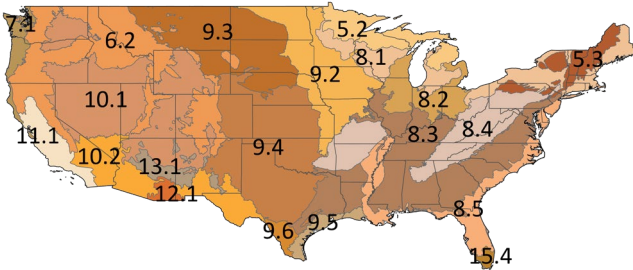
$$\widehat{elast}_{it} = \hat{\beta}_1 + \hat{\beta}_2 * LF_i + \hat{\beta}_3 \ln(Dist_i) + \hat{\beta}_4 \ln(Area_i) + \hat{\beta}_5 U_i + \hat{\beta}_E E_i + \hat{\beta}_S S_i$$

Nation I Baseline Results

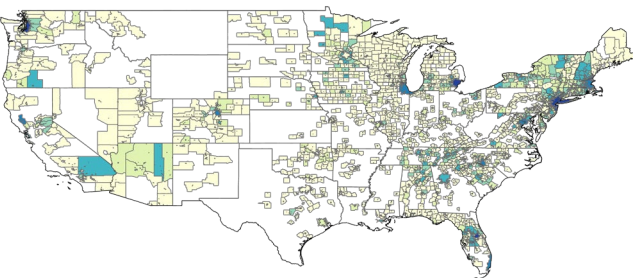
Parameter	Estimate	Std. Error	Parameter	Estimate	Std. Error	Parameter	Estimate	Std. Error
const	6.832***	(0.213)	Secchi * AL	-0.612	(0.720)	Secchi * OR	-0.556**	(0.206)
Secchi ^{1,2}	0.141	(0.075)	Secchi * AR	-0.535***	(0.102)	Secchi * PA	-2.437***	(0.058)
Secchi * <150 m	0.026**	(0.009)	Secchi * CO	-0.440***	(0.106)	Secchi * RI	-0.101	(0.071)
Secchi * Lake Distance	-0.037***	(0.005)	Secchi * CT	-0.491	(0.317)	Secchi * SC	-1.455**	(0.448)
Secchi * Lake Area	0.026**	(0.010)	Secchi * DE	1.063	(0.585)	Secchi * SD	-1.460***	(0.121)
Secchi * Urban	-0.008	(0.024)	Secchi * FL	-0.007	(0.076)	Secchi * TN	-0.116	(0.129)
Secchi * Ecoregion 5.2	0.041	(0.044)	Secchi * IA	-0.213	(0.141)	Secchi * TX	-2.075***	(0.476)
Secchi * Ecoregion 5.3	0.019	(0.030)	Secchi * IL	-0.068	(0.137)	Secchi * VA	-0.114	(0.086)
Secchi * Ecoregion 6.2	0.524***	(0.100)	Secchi * IN	0.397	(0.856)	Secchi * VT	0.058	(0.377)
Secchi * Ecoregion 7.1	0.475*	(0.205)	Secchi * LA	0.200**	(0.068)	Secchi * WA	-0.486*	(0.211)
Secchi * Ecoregion 8.2	-0.025	(0.123)	Secchi * MA	-0.046	(0.070)	Secchi * WI	0.056	(0.142)
Secchi * Ecoregion 8.3	0.077	(0.063)	Secchi * ME	2.266***	(0.123)	<150 m	0.125***	(0.009)
Secchi * Ecoregion 8.4	-0.015	(0.077)	Secchi * MI	-0.077	(0.079)	Lake Distance	-0.098***	(0.005)
Secchi * Ecoregion 8.5	0.017	(0.054)	Secchi * MN	0.011	(0.056)	Lake Area	-0.001	(0.011)
Secchi * Ecoregion 9.2	0.101	(0.107)	Secchi * NC	-0.155	(0.323)	Median Income	0.140***	(0.014)
Secchi * Ecoregion 9.3	-0.030	(0.088)	Secchi * ND	-0.129	(0.097)	Slope	0.021***	(0.002)
Secchi * Ecoregion 9.4	0.532***	(0.088)	Secchi * NE	-0.016	(0.146)	Elevation	-0.007	(0.027)
Secchi * Ecoregion 10.2	0.396***	(0.099)	Secchi * NH	-0.026	(0.061)	Lot Size	0.104***	(0.004)
Secchi * Ecoregion 11.1	0.718***	(0.099)	Secchi * NJ	0.034	(0.070)	Building Age	-0.118***	(0.003)
Secchi * Ecoregion 13.1	-0.072	(0.062)	Secchi * OH	0.212	(0.320)	Building Size	0.562***	(0.010)
Secchi * Ecoregion 15.4	-0.046	(0.102)	Secchi * OK	-1.244***	(0.092)	Quarter 2	0.045***	(0.002)
						Quarter 3	0.052***	(0.002)
						Quarter 4	0.018***	(0.002)

Notes: N = 587,327 Standard Errors Clustered at Tract Level. *p<.05 **p<.01 ***p<.001

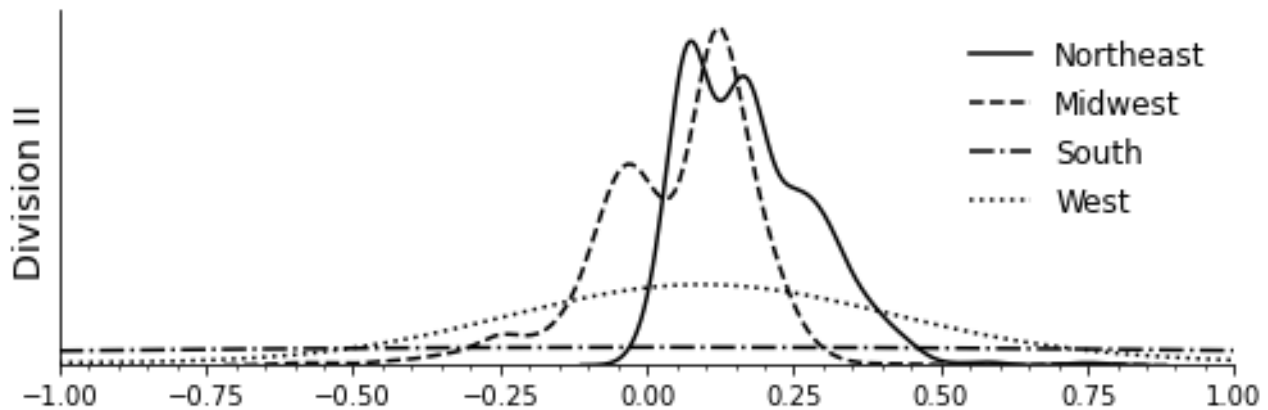
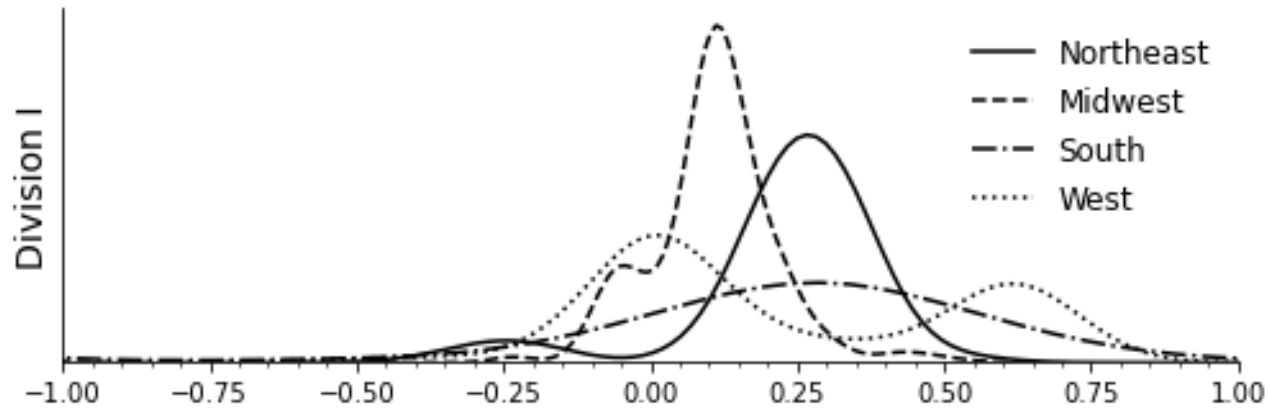
Ecoregions



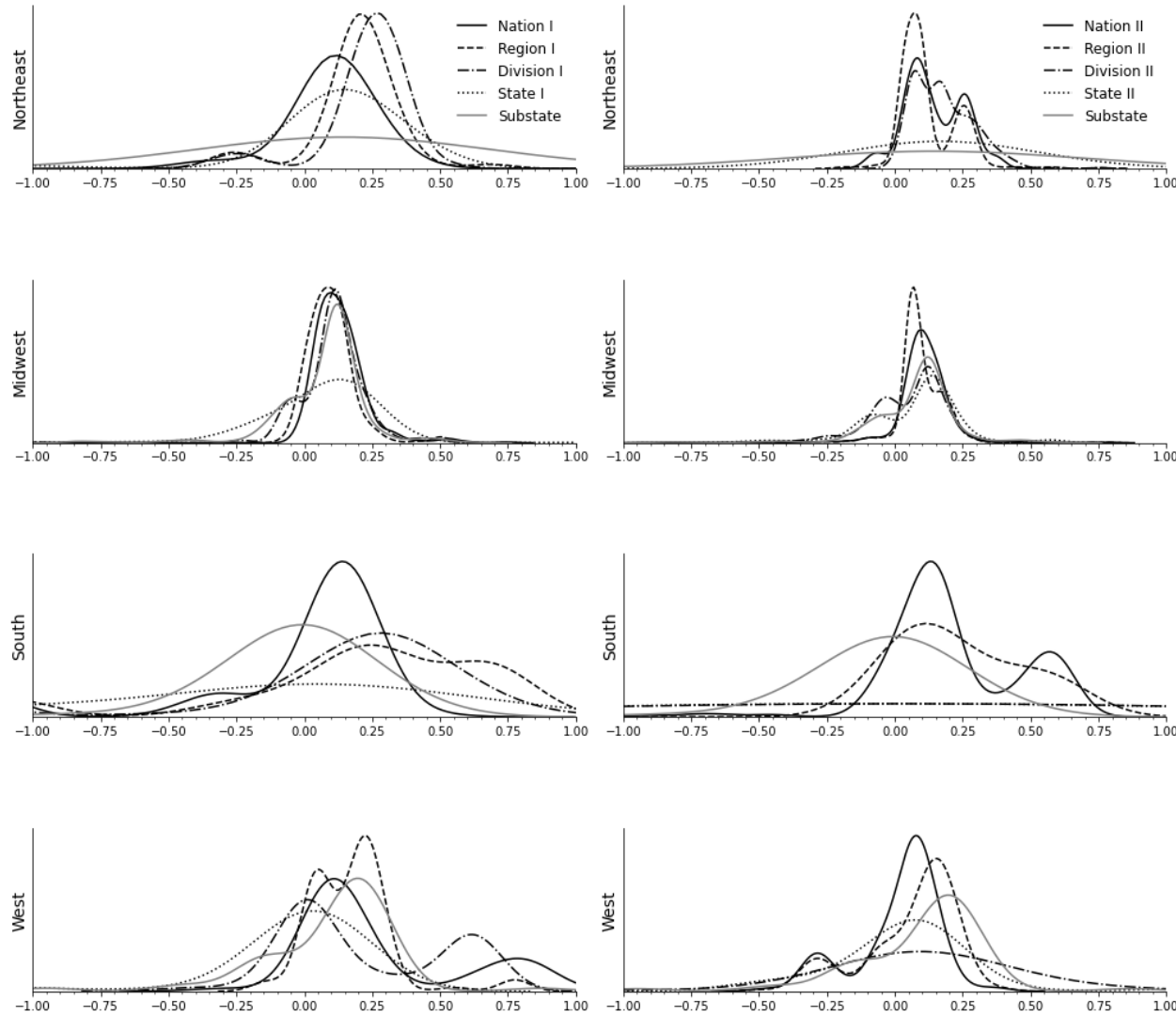
Sale Density



Regional Heterogeneity



- Considering baseline elasticity estimates within 150m from lakefront
- Holding spatial scale constant at the Division level plot distributions by region
- Densities rescaled to 1 for each plot



Variation by Market Boundaries

- Considering baseline elasticity estimates within 150m from lakefront
- Holding each region constant plot distributions by spatial scale
- Densities rescaled to 1 for each plot

Conclusions

- The effects of lake water quality on sale prices may not be generalizable at a national scale
 - Related to political and ecological boundaries
- Investigators should proceed with care when defining market boundaries for hedonic models
 - No one size fits all approach
 - Need to test the sensitivity of results to different boundaries
- Large and small scale hedonic models are complimentary
 - In the Midwest and Northeast, we can define lake housing market more broadly
 - In the South and the West, case studies may be more appropriate

Future Research

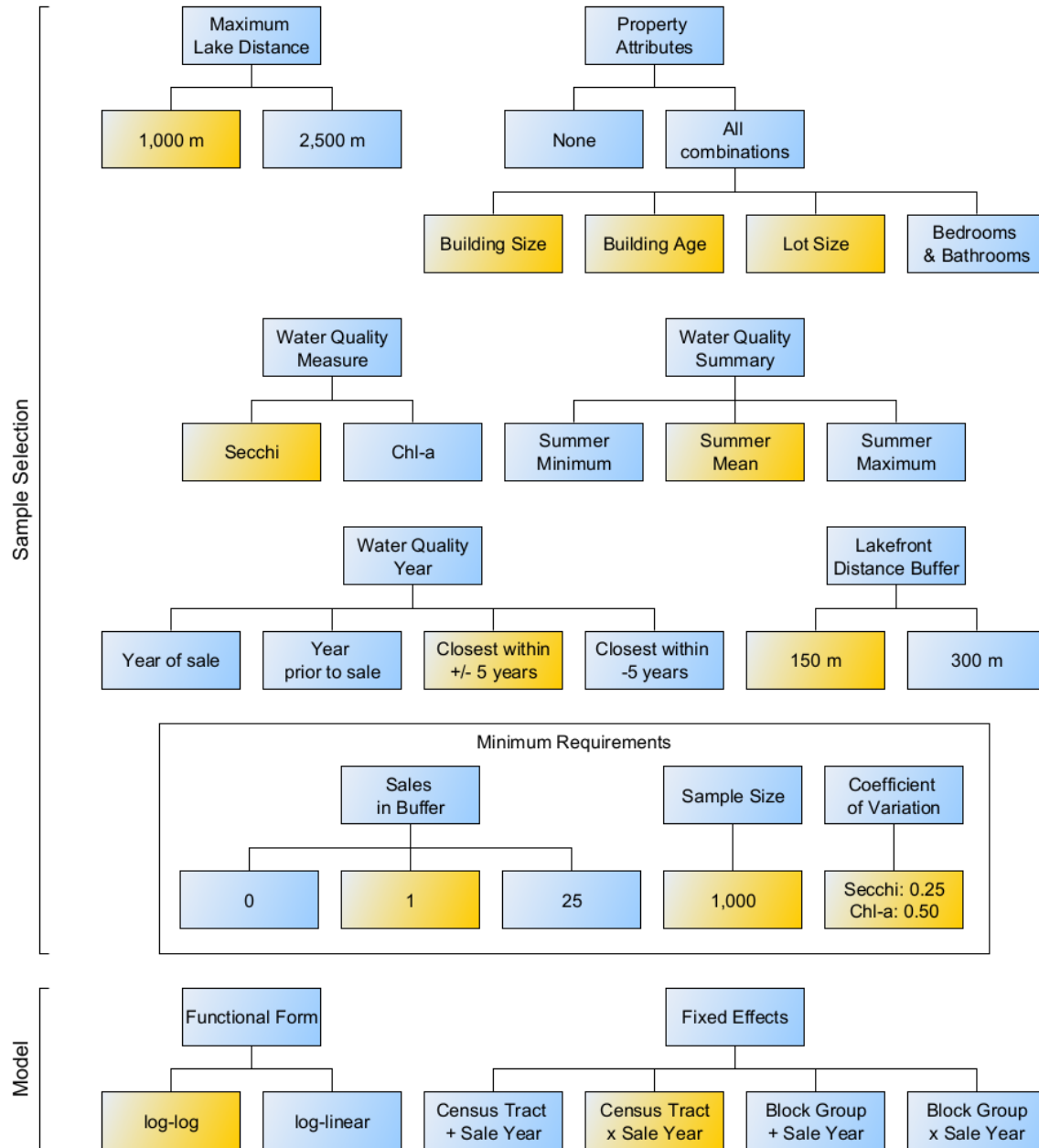
- Lots more work to be done!
- Targeted studies in areas with limited data
- Our results can lay the groundwork for future meta-analyses
 - To better understand ecological and geopolitical patterns underlying observed spatial heterogeneity
- Spatially-referenced elasticity estimates can be linked to hydrological models to assess different policy outcomes

Thank you!

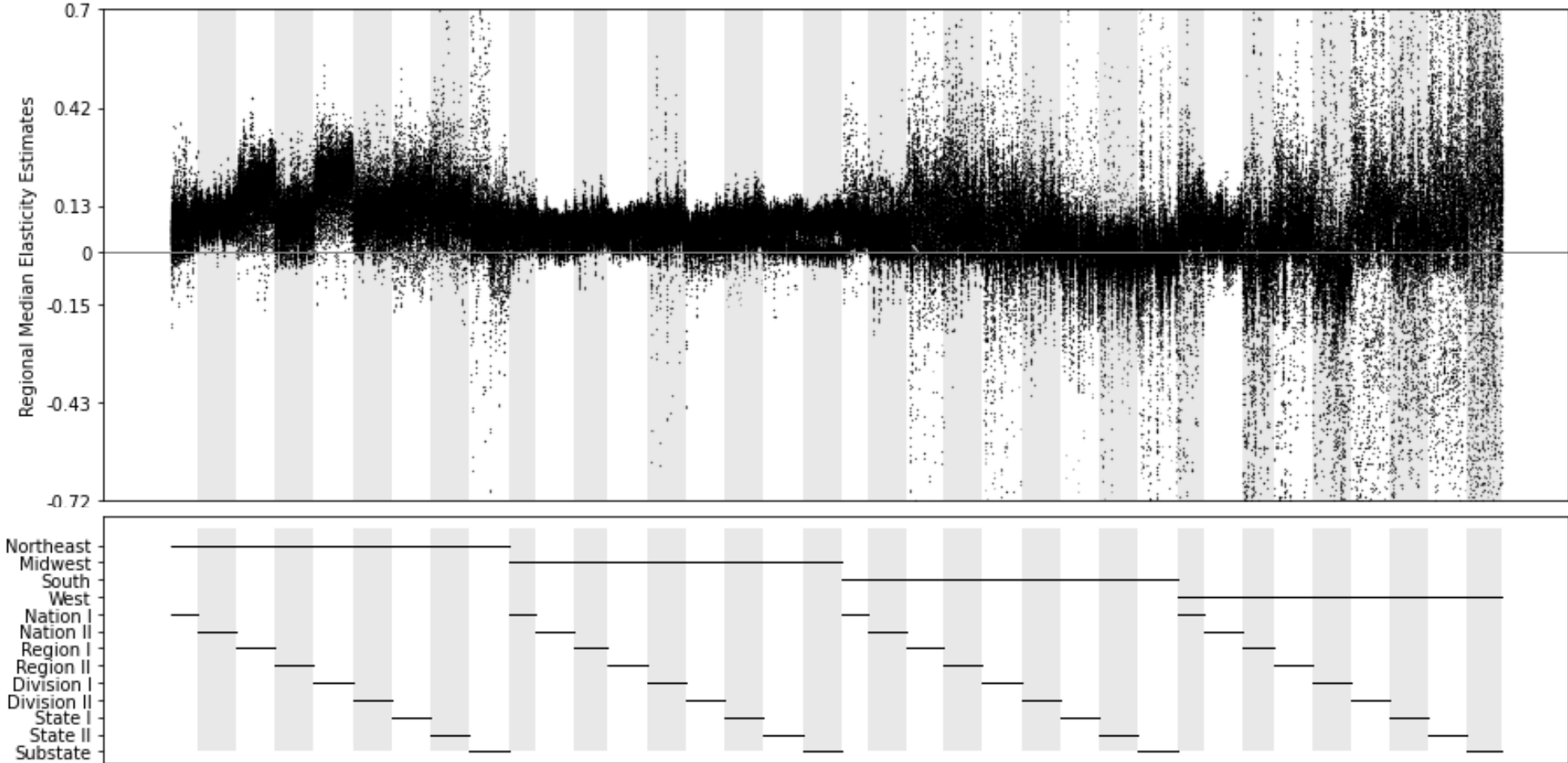
- Kristen Swedberg
- swedkm@vt.edu

Methodological Combinations

- Consider wide range of sample selection criteria and model specifications
- Baseline highlighted in yellow
- Set minimum sample size and coefficient of variation based on prior literature



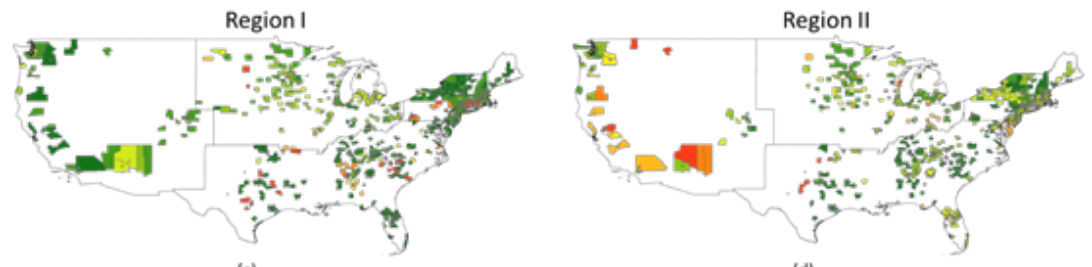
Robustness





(a)

(b)



(c)

(d)



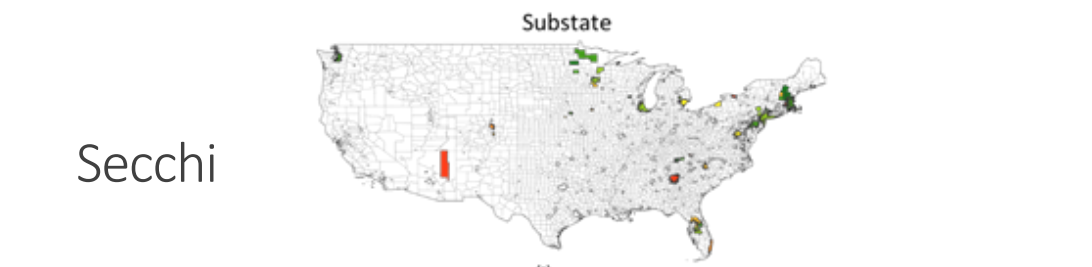
(e)

(f)



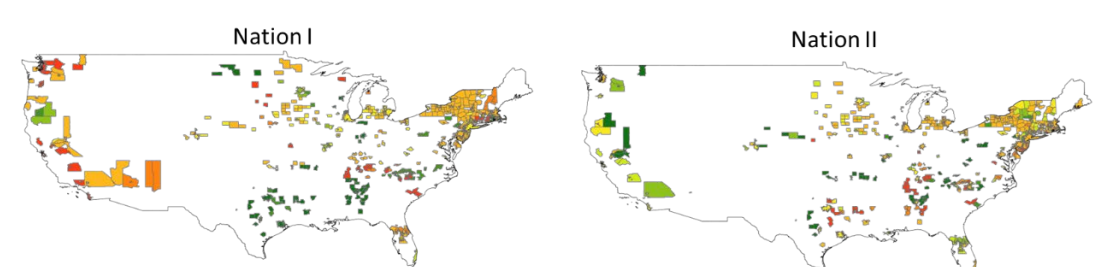
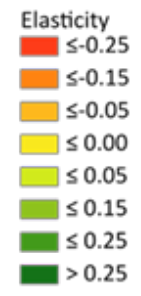
(g)

(h)



(i)

Secchi



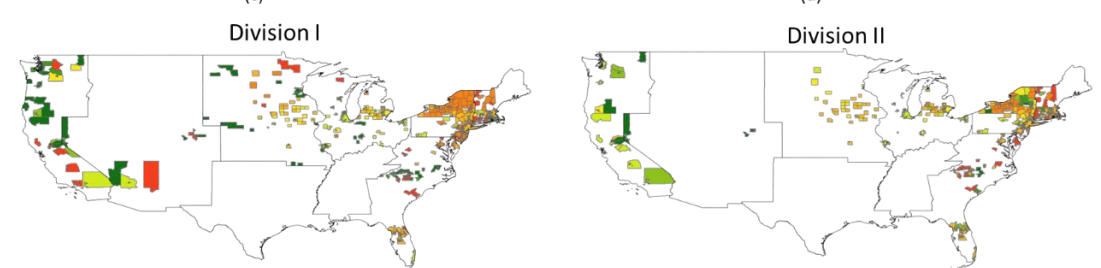
(a)

(b)



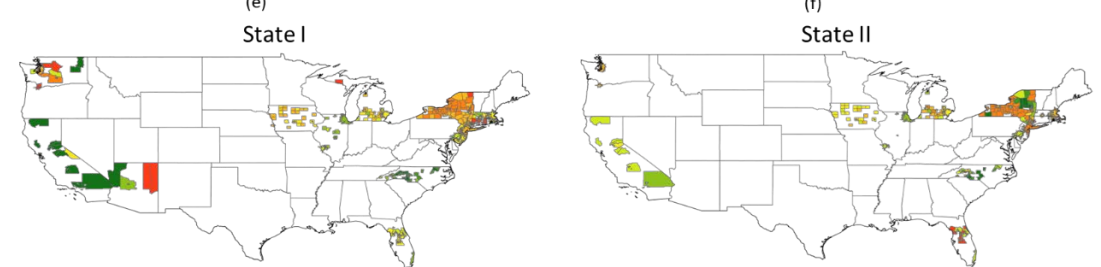
(c)

(d)



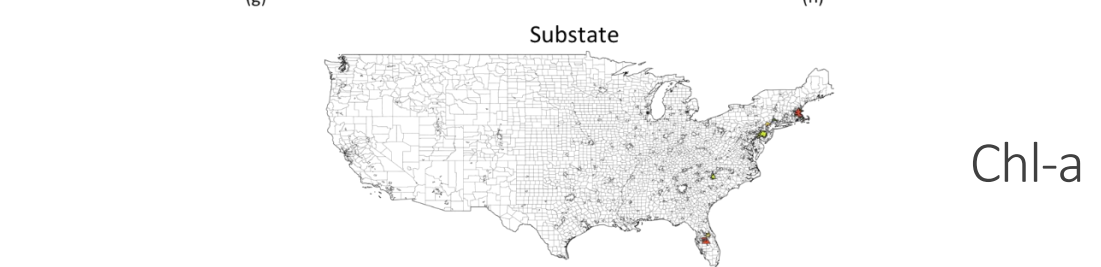
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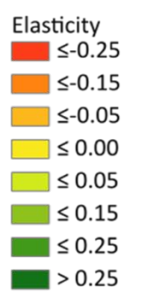
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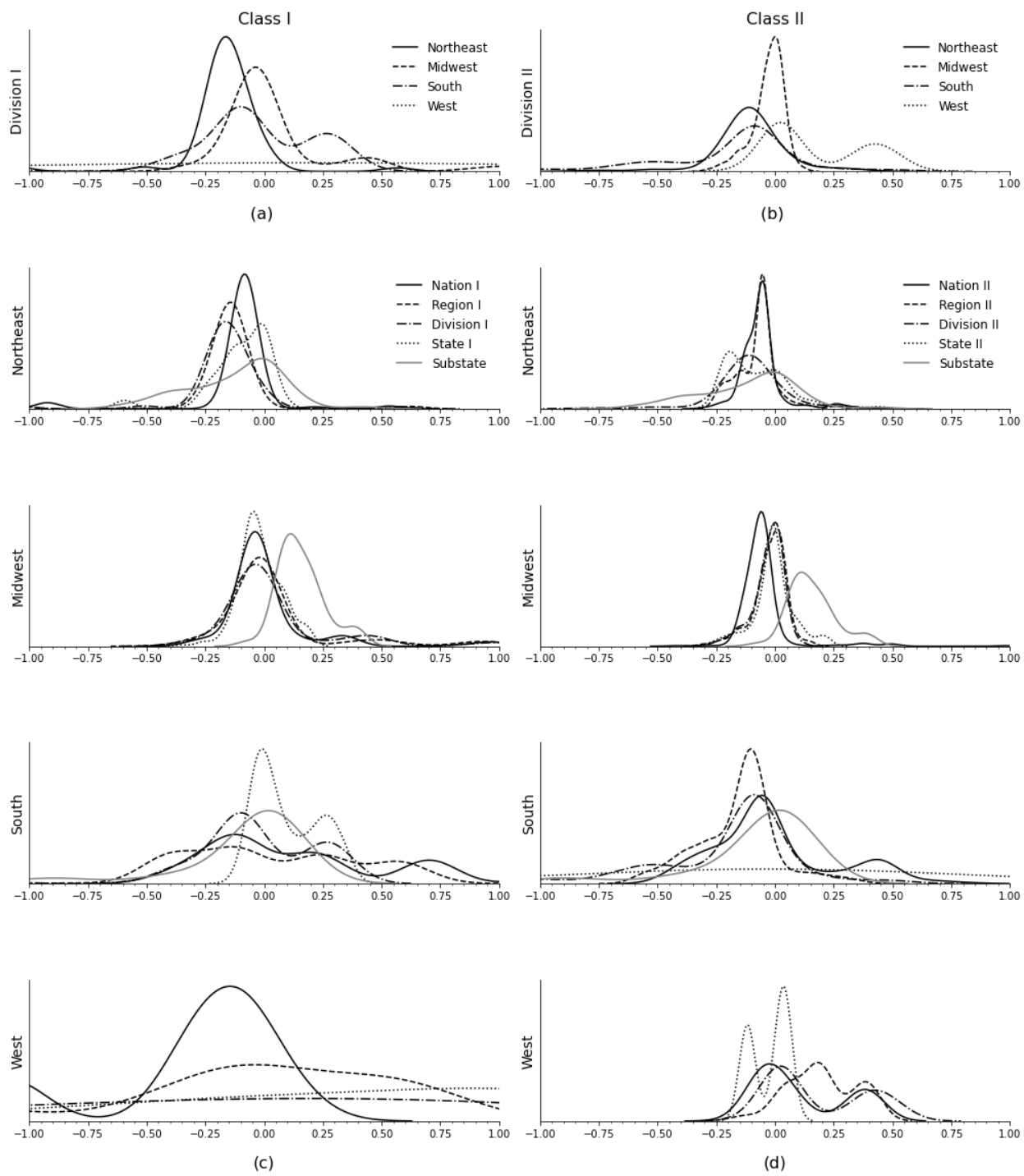
(h)



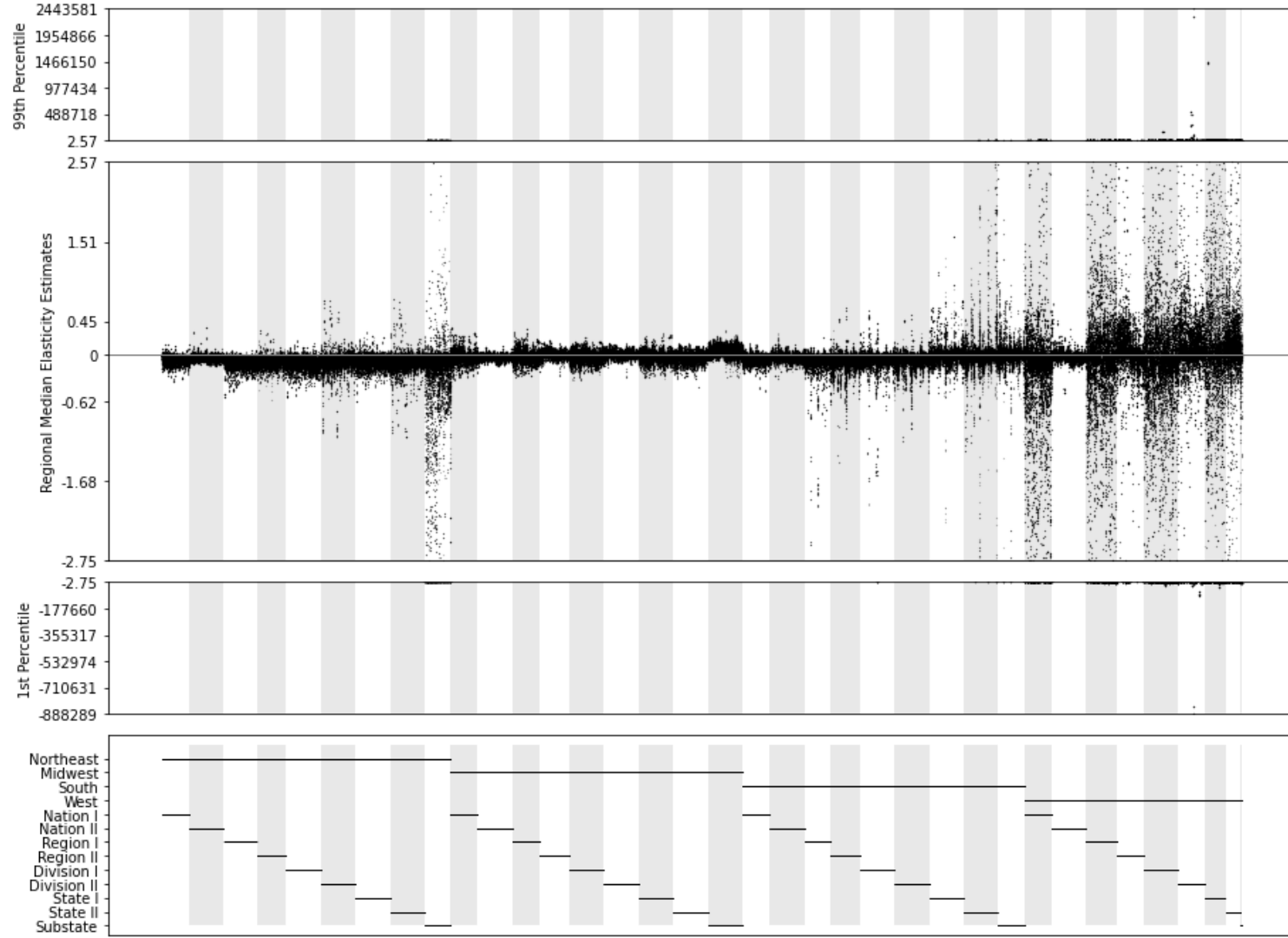
(i)

Chl-a





Chl-a Distributions



ChI-a Robustness