Property Values and Water Quality:

A Nationwide Meta-Analysis and the Implications for Benefit Transfer

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Presentation for the
USDA Sponsored workshop:
Applications and Potential of
Ecosystem Services Valuation within USDA – Advancing the Science
April 23-24, 2019; Washington, DC

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The data/research described in this presentation has been funded in part by the U.S. Environmental Protection Agency (EPA) Contract No. EP-C-13-039 to Abt Associates. The views expressed in this presentation are those of the authors and do not necessarily represent the views or policies of the US Environmental Protection Agency (EPA). Mention of trade names or commercial products does not constitute EPA endorsement or recommendations for use.

USDA Programs
(e.g., CRP, CSP, EQIP)
Reduce pollutants into waterways
(e.g., nutrients and sediment)
Improve aquatic ecosystems

Hedonic Property Value Methods

Estimate how local amenities (e.g., water quality) affect home values

Hedonic literature examining water quality goes back over 50 years (David, 1968)

Objective

Summarize literature, and synthesize results using meta-analysis

Estimate unit value and value functions of capitalization effects for purposes of benefit transfer

*"**Meta-analysis** is the quantitative synthesis of multiple primary studies… allows [for] generalizations."*

(Nelson, 2013)

Benefit Transfer – practice of applying estimated values from studies of other regions or policies, to a policy/action of interest.

Unit Values

Value Functions

Meta-Dataset

65 studies identified

- Examine residential property values and water quality

Meta-Dataset

65 studies identified

- Examine residential property values and water quality

Studies excluded if:

- Not a primary study
- Unpublished version of a later published study
- Not a study of surface water quality
- Outside of U.S.
- Only used subjective water quality ratings

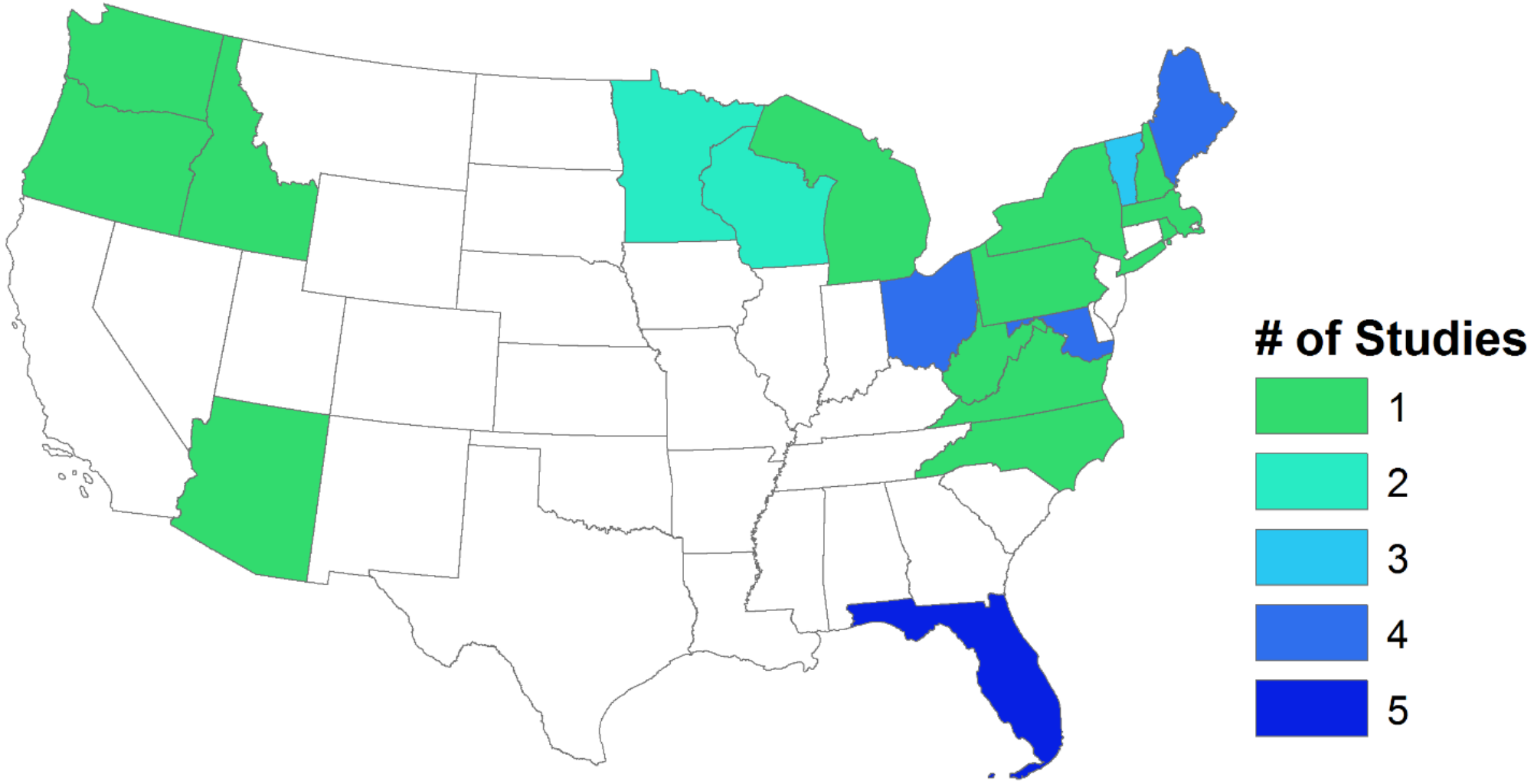
36 studies included in meta-dataset

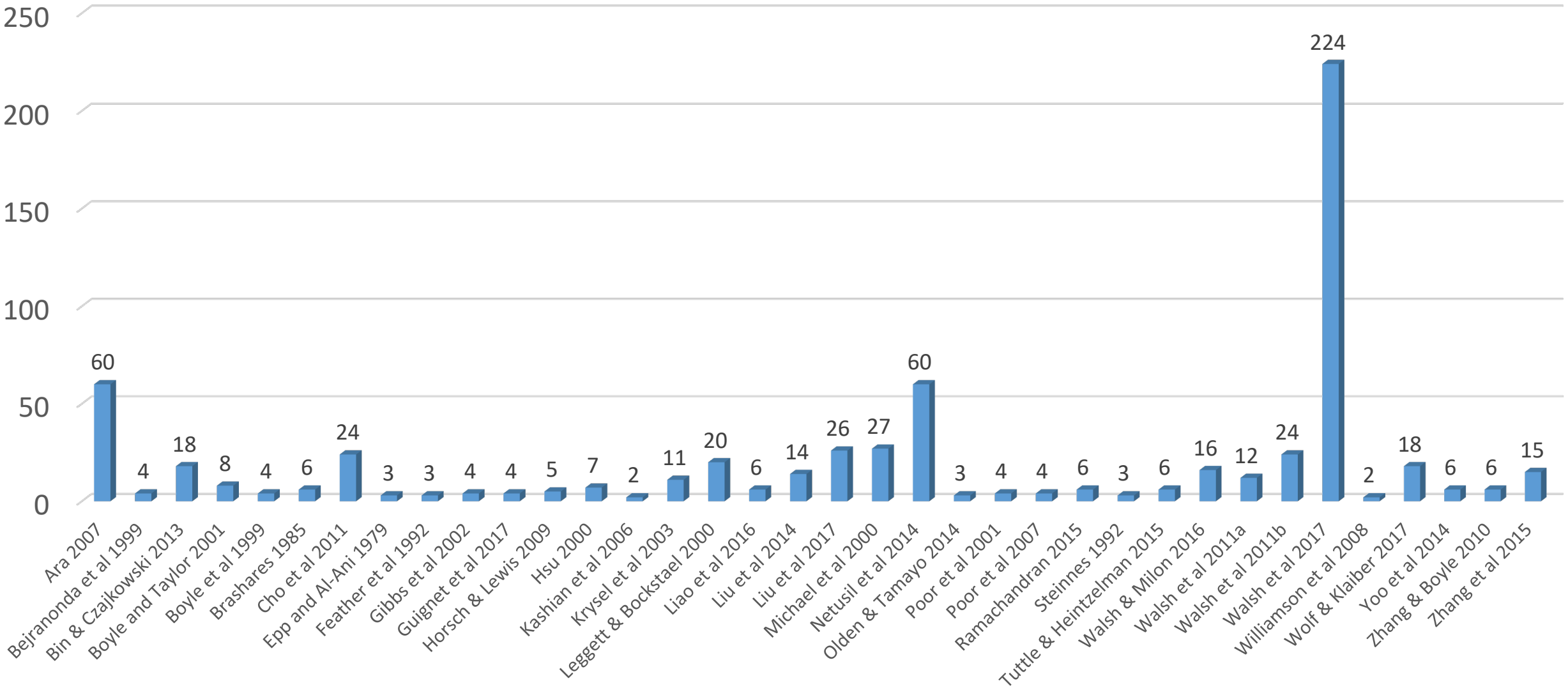
Lakes
(25 studies*)

Estuaries
(6 studies)

Rivers
(3 studies*)

Small Rivers
(3 studies)

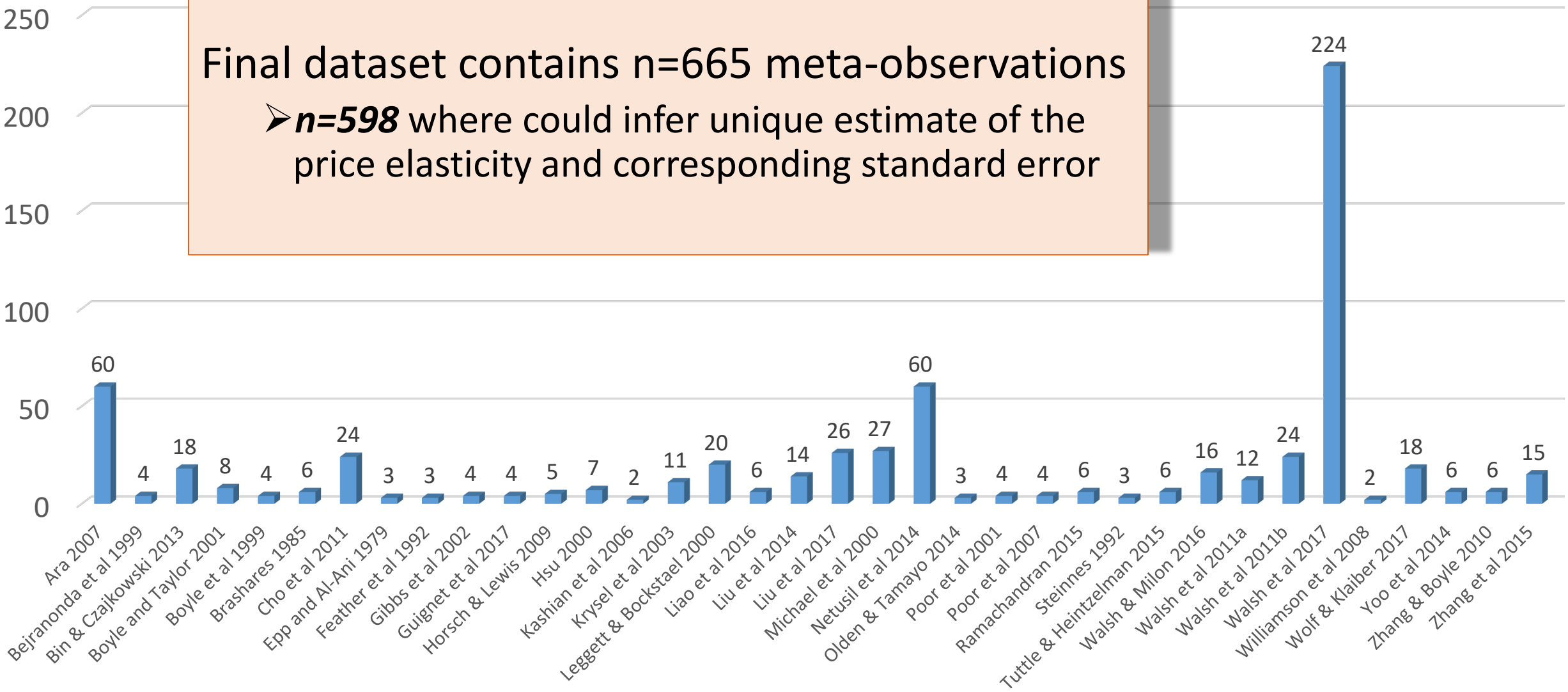

# of Studies
1
2
3
4
5



Studies included in Meta-dataset

Final dataset contains n=665 meta-observations

- ***n=598*** where could infer unique estimate of the price elasticity and corresponding standard error



Studies included in Meta-dataset

Formatting Common Measures of Price Impacts

Price elasticity and semi-elasticity

- Study by study derivation based on initial functional form
- Standard errors inferred via Monte Carlo simulations (10,000 draws)

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Price elasticity and semi-elasticity

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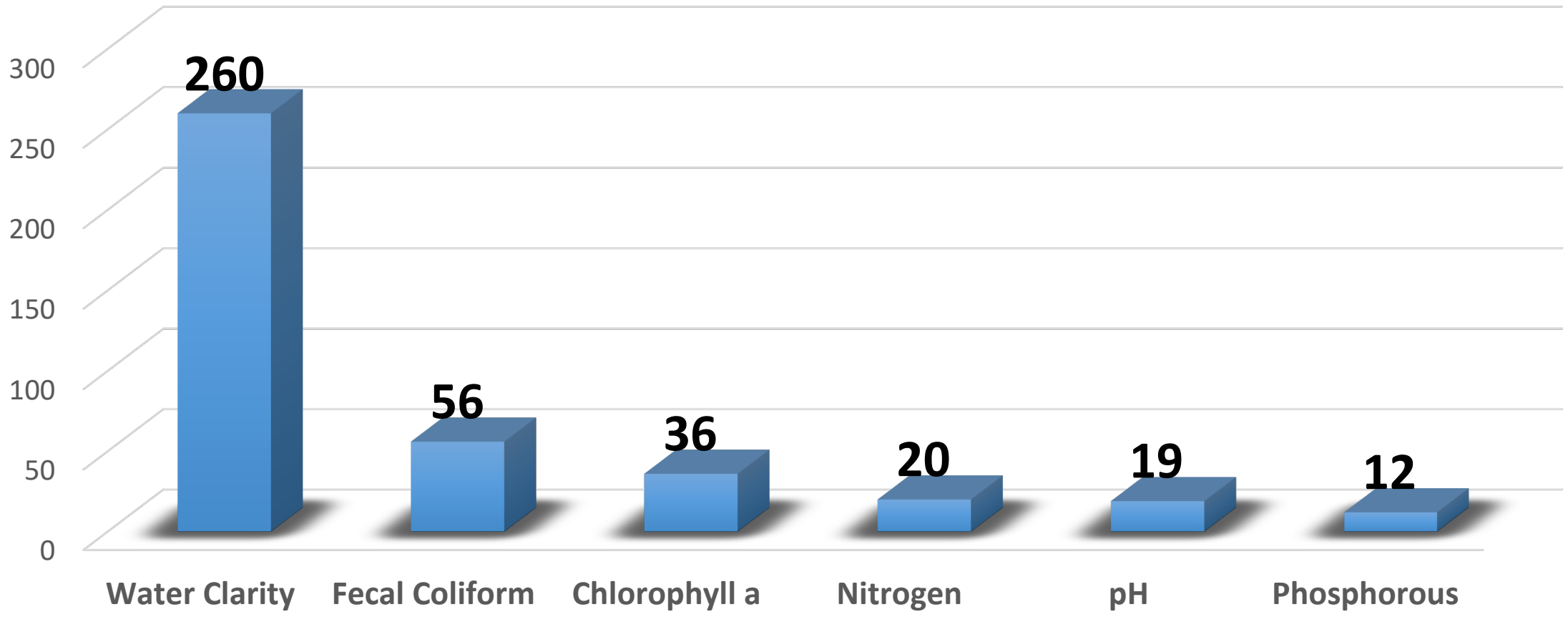
Common distances

- Waterfront and non-waterfront w/in 500 meters

Number of meta-observations by water quality measure



Meta-analysis

Unit Values

Value Functions

Cluster-adjusted Random Effect Size Weights

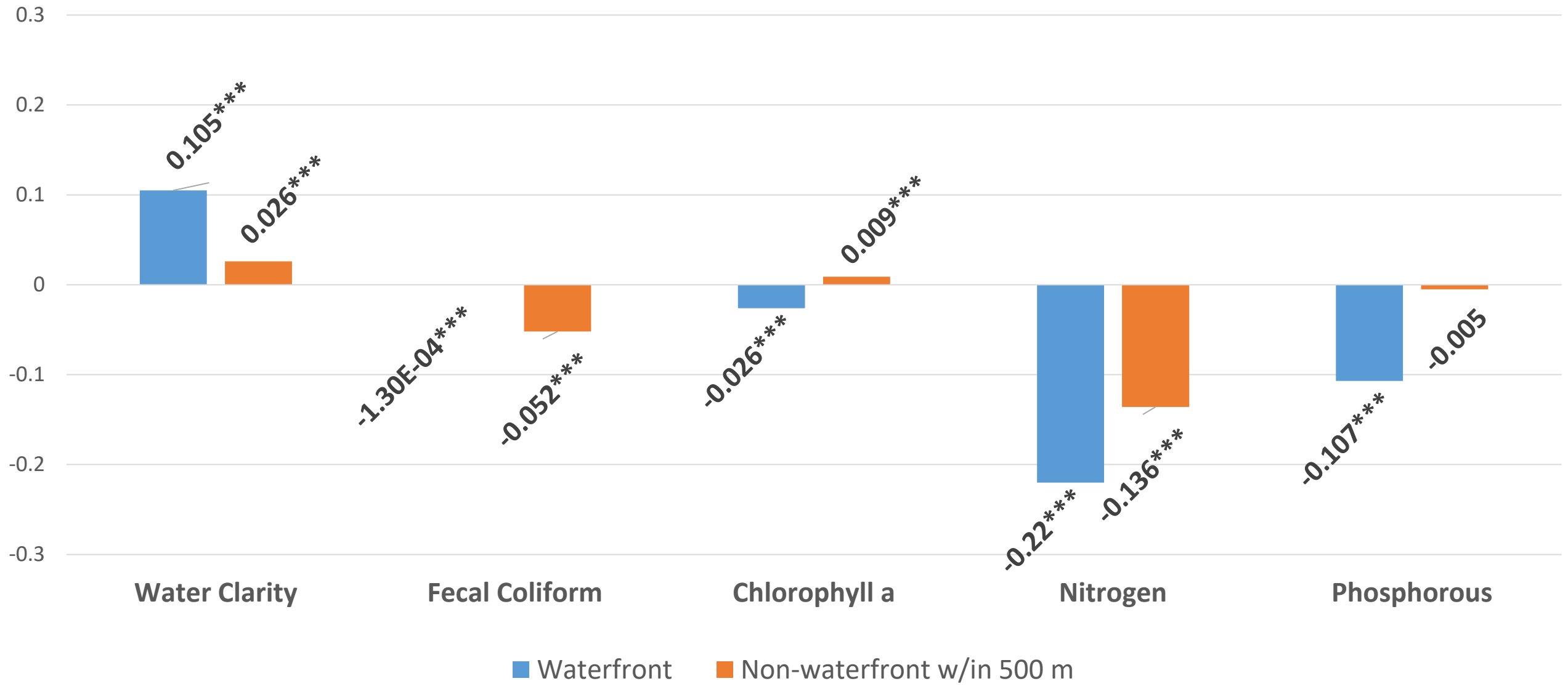
Random Effect Size (RES) Weights –

- Account for statistical precision of primary estimates

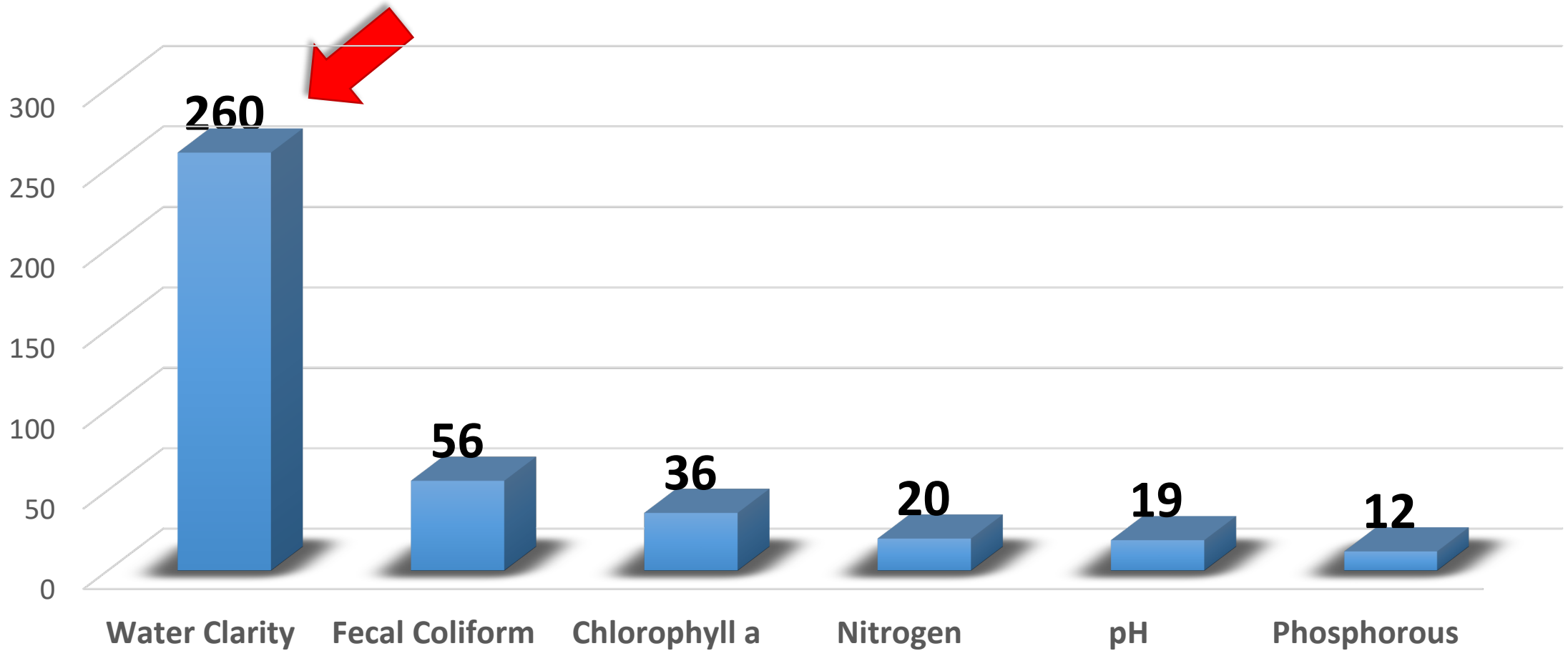
Clusters defined as unique housing markets

- Account for numerous estimates of same “true” elasticity for the same housing market and waters

Mean Elasticity Estimates



Number of meta-observations by water quality measure



Meta-analysis

Unit Values

Value Functions

Meta-regression Model: Water clarity (secchi disk depth)

Home price elasticity estimate *i* for distance bin *d* in cluster (housing market) *j*

Waterfront dummy

Estuary dummy

Baseline Water Quality

Region dummies (NE, S, MW, W)

$$\hat{\varepsilon}_{idj} = \beta_0 + wf_{idj}\beta_1 + estuary_j\beta_2 + WQ_{ij}\beta_2 + \boldsymbol{region}_j\boldsymbol{\beta}_3 + e_{idj}$$

$$c_j + u_{idj}$$

Cluster-specific Effect

Error term

1. **Random Effects (RE) Panel Model**
2. **Mundlak Model**

   (Mundlak, 1978; Boyle & Wooldridge, 2018)

Random Effects (RE) Panel Meta-regression Model

(dependent variable: predicted house price elasticity)

VARIABLES	(1)				
waterfront	0.0791***				
estuary					
mean clarity					
midwest					
south					
west					
constant	0.0257*				

Random Effects (RE) Panel Meta-regression Model

(dependent variable: predicted house price elasticity)

VARIABLES	(1)	(2)			
waterfront	0.0791***	0.0498**			
estuary		-0.0546*			
mean clarity					
midwest					
south					
west					
constant	0.0257*	0.0713**			

Random Effects (RE) Panel Meta-regression Model

(dependent variable: predicted house price elasticity)

VARIABLES	(1)	(2)	(3)		
waterfront	0.0791***	0.0498**	0.0457**		
estuary		-0.0546*			
mean clarity			0.0146**		
midwest					
south					
west					
constant	0.0257*	0.0713**	0.0138		

Random Effects (RE) Panel Meta-regression Model

(dependent variable: predicted house price elasticity)

VARIABLES	(1)	(2)	(3)	(4)	
waterfront	0.0791***	0.0498**	0.0457**	0.0347	
estuary		-0.0546*			
mean clarity			0.0146**		
midwest				-0.0318	
south				-0.0865***	
west				-0.0622	
constant	0.0257*	0.0713**	0.0138	0.1065***	

Random Effects (RE) Panel Meta-regression Model

(dependent variable: predicted house price elasticity)

VARIABLES	(1)	(2)	(3)	(4)	(5)
waterfront	0.0791***	0.0498**	0.0457**	0.0347	0.0381*
estuary		-0.0546*			-0.0015
mean clarity			0.0146**		-0.0103
midwest				-0.0318	-0.0513
south				-0.0865***	-0.1239*
west				-0.0622	-0.0609
constant	0.0257*	0.0713**	0.0138	0.1065***	0.1517

Mundlak Meta-regression Model

(dependent variable: predicted house price elasticity)

VARIABLES	(1)	(2)	(3)	(4)	(5)
waterfront	0.0640***	0.0602***	0.0607***	0.0581***	0.0579***
waterfront cluster mean	0.0471	-0.0571	-0.1744**	-0.2279***	-0.2566***
estuary		-0.0693***			0.0183
mean clarity			-0.0273		-0.0378
clarity cluster mean			0.0597		0.0469
midwest				-0.0806***	-0.0693**
south				-0.1832***	-0.1781***
west				-0.0622	-0.0633
constant	0.0024	0.1118***	0.0856***	0.3109***	0.2969***

Absolute Value of Transfer Error

	RES Mean Value Transfer	Meta-regression Model Function Transfer				
		(1)	(2)	(3)	(4)	(5)
Out-of-sample transfer error	0.13504					
RE Panel Meta-regression		0.13502	0.13508	0.13262	0.14011	0.14563
Mundlak Meta-regression		0.13395	0.14074	0.13973	0.15739	0.16307

USDA Programs

(e.g., CRP, CSP, EQIP)

→

Reduce pollutants into waterways

(e.g., nutrients and sediment)

→

Improve aquatic ecosystems

Implications for Benefit-Transfer

If water quality models quantify change in:

- Water clarity

  → Function transfer using RE Panel accounting for baseline clarity

- Fecal Coliform, Chlorophyll A, Nitrogen, pH, and Phosphorous

  → Value transfer

Combine with spatial data of waterbodies, housing, and housing values → ***BenSPLASH*** (Corona et al., 2019; session 6 today)

Conclusion

Meta-analysis provides tool for valuing improvements in water quality and aquatic ecosystem services

Plan to make meta-analysis and meta-dataset publicly available

Plan to periodically update meta-dataset

- Other waterbody types
- Other regions
- More water quality measures

Thank you!

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STATE UNIVERSITY

Appendix

Meta-analysis widely used to value environmental commodities

- Nelson and Kennedy (2009) identified 140 meta-analyses in environment and resource economics, half of which published since 2004

Several meta-analyses of hedonic property value studies of environmental commodities

- Air pollution (PM) (Smith and Huang, 1993, 1995)
- Contaminated sites (Guignet et al., 2018; Kiel and Williams, 2007; Messer et al., 2006)
- Open space (Mazzotta et al., 2014)
- Tree cover (Siriwardena et al., 2016)
- Airport noise (Nelson, 2004)
- Railway stations (Debrezion et al., 2007)

Hedonic property value studies on water quality

First application to water quality by David (1968)

A few studies in `70s and `80s

Many studies published in mid-1990s to early 2000s

- Focused on waterfront homes around lakes
- Primarily in Northeast US

More recent literature covers:

- Additional geographic areas
- Other types of waterbodies (e.g., estuaries, rivers)
- Examine impacts on non-waterfront homes

Identifying candidate studies

Literature search from October 2016 to August 2017

Review past literature reviews and relevant publications

Searched relevant databases

- Google, Google Scholar, EBSCO, JSTOR, Ag Econ Search, Science Direct
- NCEE, NBER, RFF working paper series; RePEc/IDEAS, SSRN

Key words includes included combinations of:

- “property values”, “hedonic”
- “water quality”, “water clarity”, “secchi disk”, “pH”, and “BOD”

Requests published and unpublished studies through ResEcon Land and Resource Economics Network (ResEcon)

Second literature search conducted by EPA’s Cincinnati library staff (August 2017)

- More comprehensive set of keywords

Identifying candidate studies

Keywords in second literature search conducted by EPA Cincinnati Library

Keyword(s) 1	Keyword(s) 2		
hedonic	water quality	fecal	designated use
hedonic price	water clarity	bacteria	swimmable
hedonic value	secchi depth	algae	fishable
house price	pH	runoff	water pollution
house value	BOD	aquatic	ecosystem service
housing value	DO	sediment	freshwater
housing price	dissolved oxygen	phosphorous	eutrophication
home value	lake quality	nitrogen	turbidity
home price	stream quality	nutrients	total suspended solids
property value	river quality	impairment	TSS
property price	estuary quality		
assessed value			

Meta-dataset Variables

Study and model details

- Year study released
- Type of publication
- Functional form

Water resource and quality metrics

- Waterbody type
- Water quality metric
- Baseline water quality levels

Region and study population

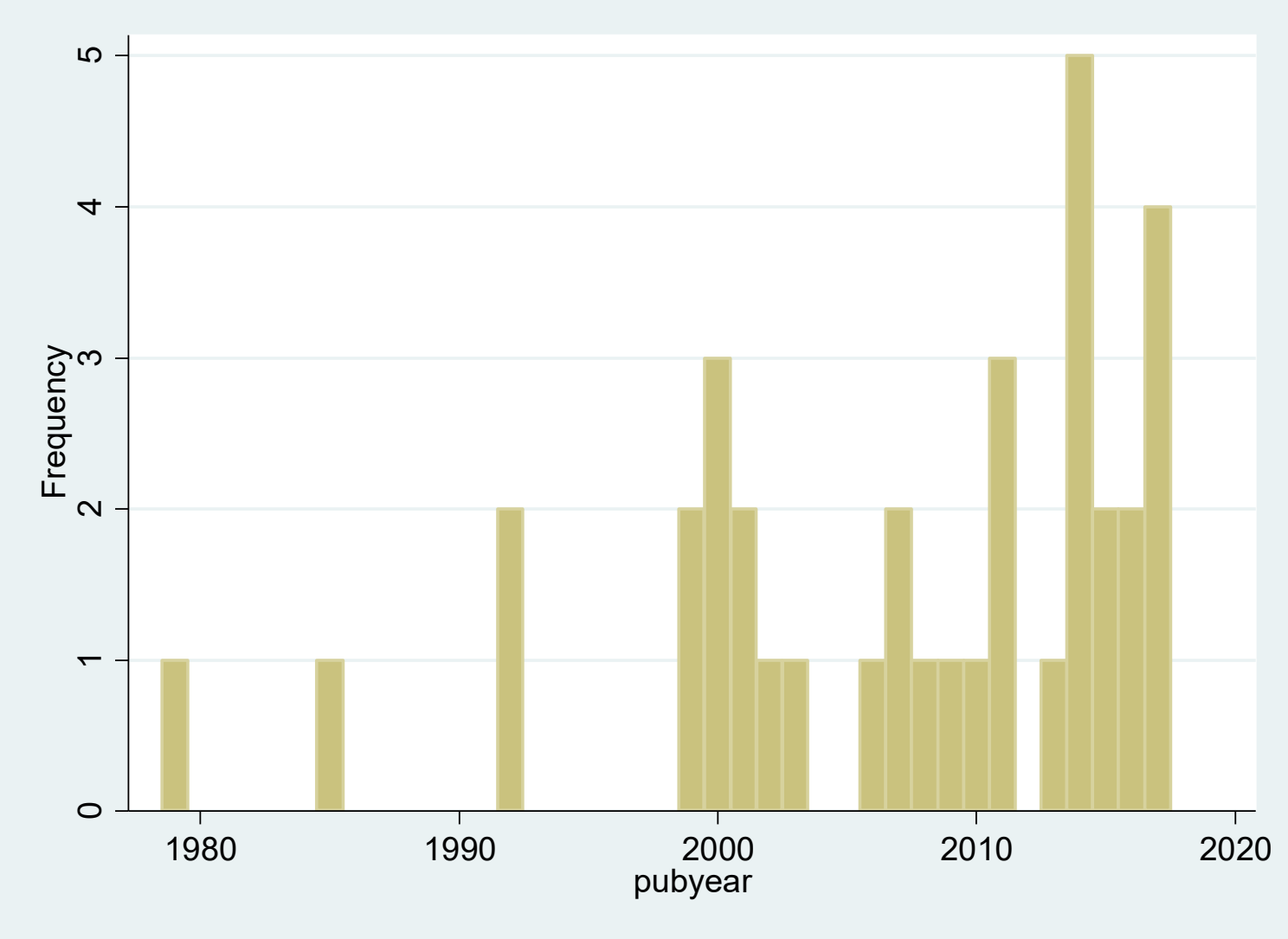
- Study area
- Type of homes and values
- Census info

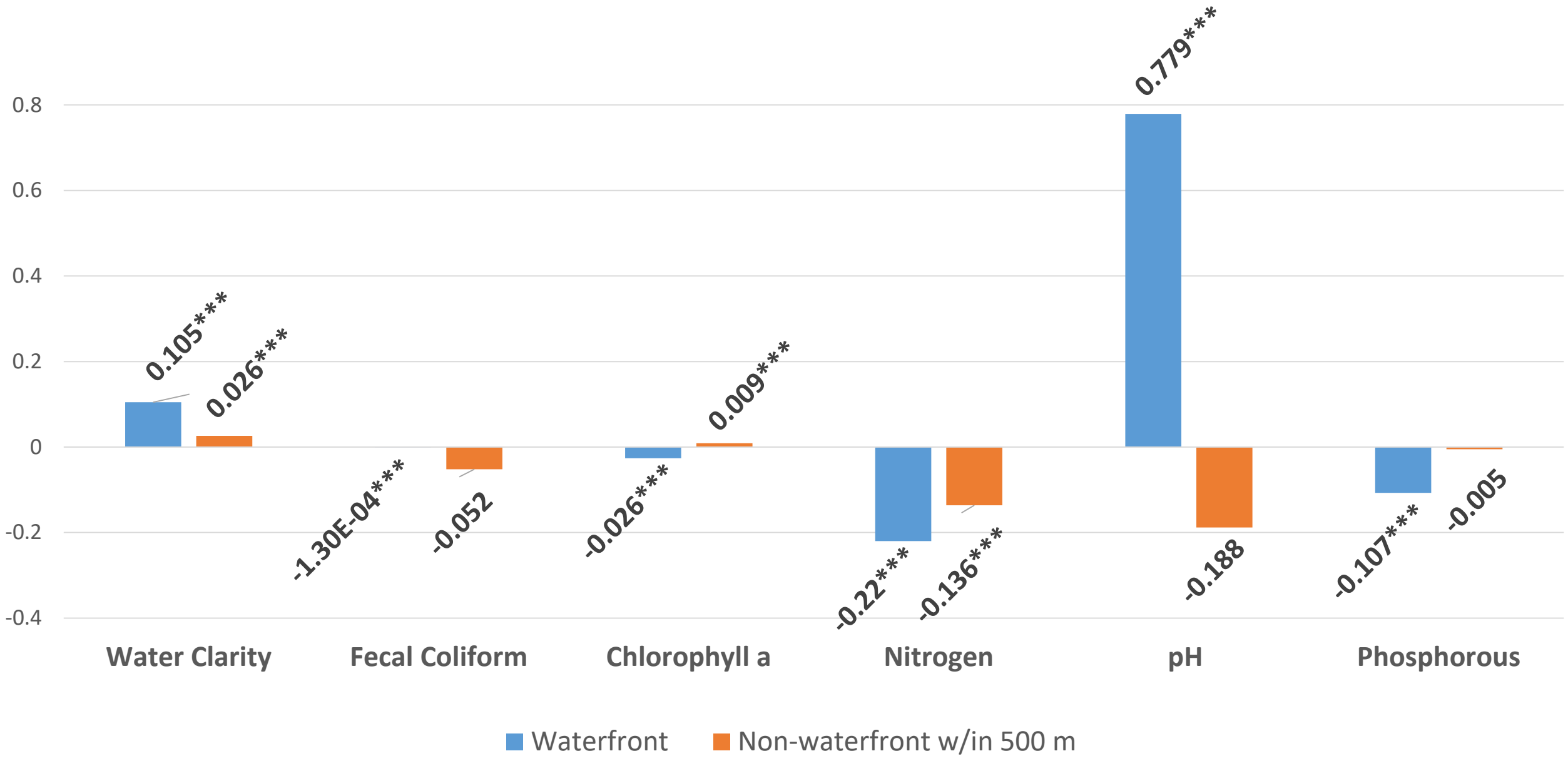
Commonly formatted estimates

- Elasticity and semi-elasticity
- Standard errors

Included Studies:

- Journal articles (26)
- Government reports (2)
- MS/PhD theses (3)
- Working papers (3)
- Other (2)




0.8
0.6
0.4
0.2
0
-0.2
-0.4
0.105***
0.026***
-1.30E-04***
-0.052
-0.026***
0.009***
-0.22***
-0.136***
0.779***
-0.188
-0.107***
-0.005
Water Clarity
Fecal Coliform
Chlorophyll a
Nitrogen
pH
Phosphorous
Waterfront
Non-waterfront w/in 500 m