Estimating Homeowners' Demand for Improved Water Quality in Lake Erie

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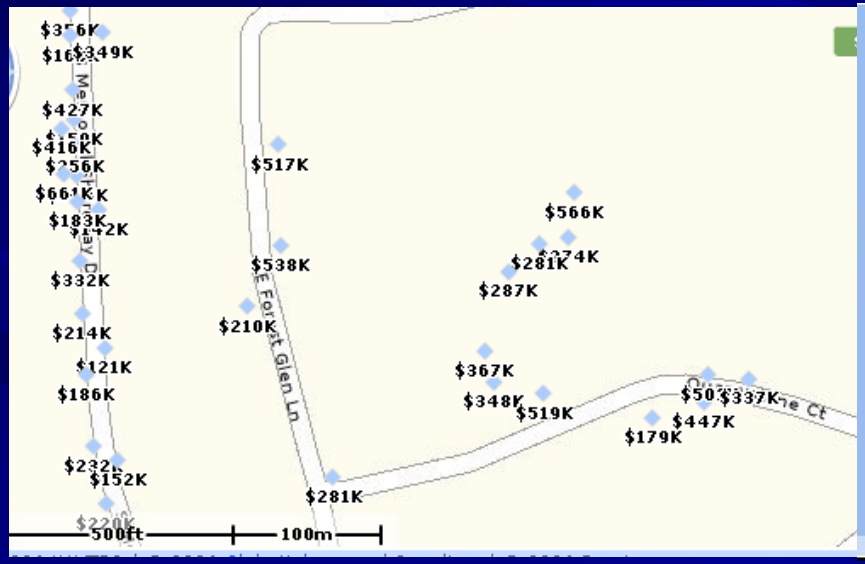
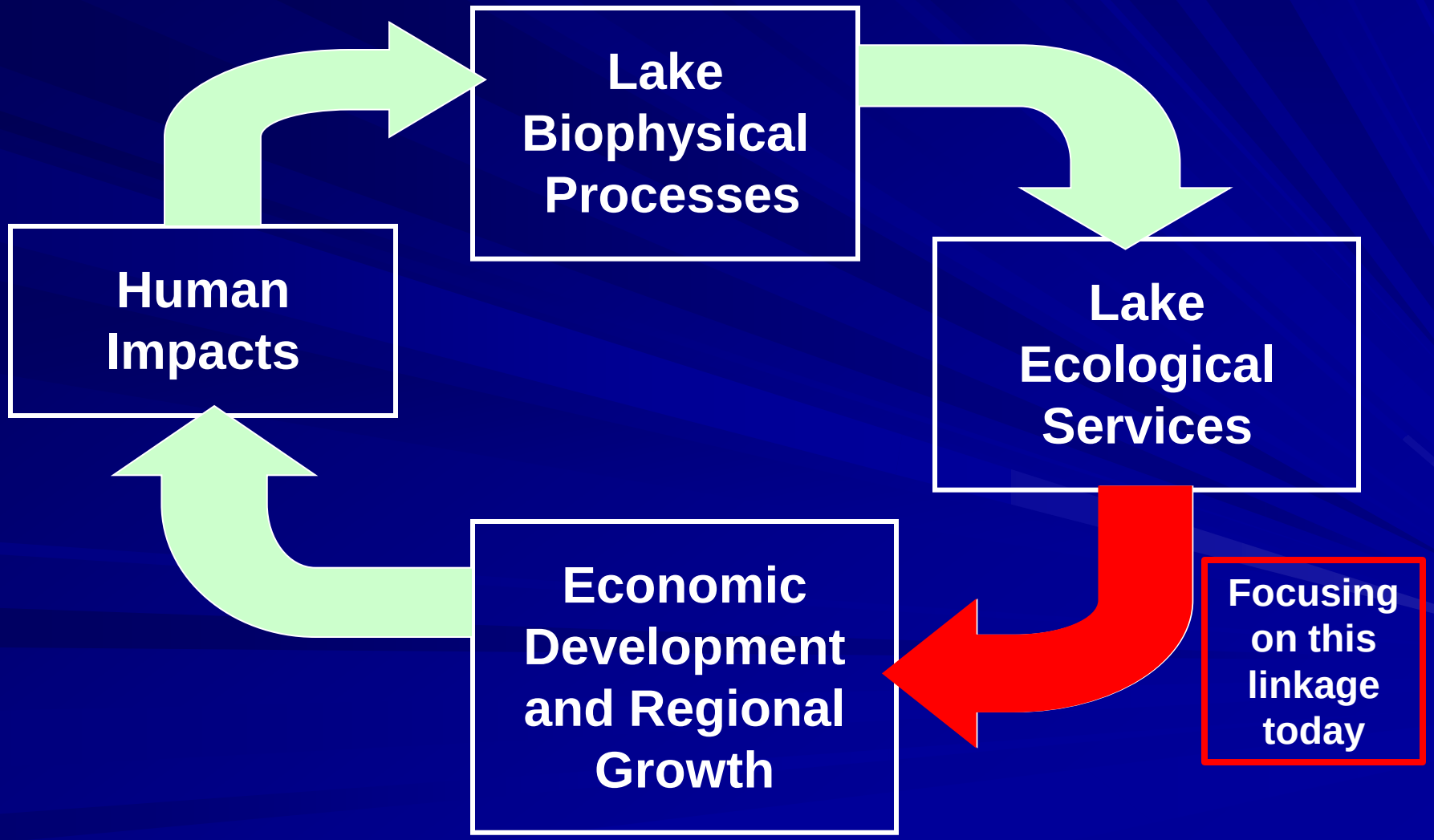
Lake Erie Amenity-Driven Growth



Economy-Lake Interactions



Research Questions

- Do changes in the water quality of Lake Erie affect the value of houses in the region?
- How important is water quality relative to other factors that influence housing values?
- What is the estimated benefit (in dollars) of an improvement in water quality to homeowners?

Research Method

- Housing = “bundle of attributes”
  - **House** (size of house, number of bathrooms)
  - **Neighborhood** and location attributes (distance to city, school quality)
  - **Environmental** variables: recreational access and water quality measures
    - Driving distance to nearest beach
    - **Swimmable water**: Fecal coliform counts (per 100 mL)
    - **Water clarity**: Secchi disk depth readings (centimeters)

Research Method

- First stage hedonic pricing model
  - Sales price is decomposed into a series of "**implicit prices**" that represent the marginal contribution of each attribute to overall price
- For example:

$$\text{Housing price}_i = p_1*(\text{Size}_i) + p_2*(\text{School quality}_i) \\ p_3*(\text{Access to work}_i) + p_4*(\text{Access to lake}_i) \\ + p_5*(\text{Water quality}_i)$$

- Interpretation of p_i = implicit price of X = the change in housing price given a marginal change in X
  - For example, p_5 = the change in housing price given a an increase in water quality

Research Method

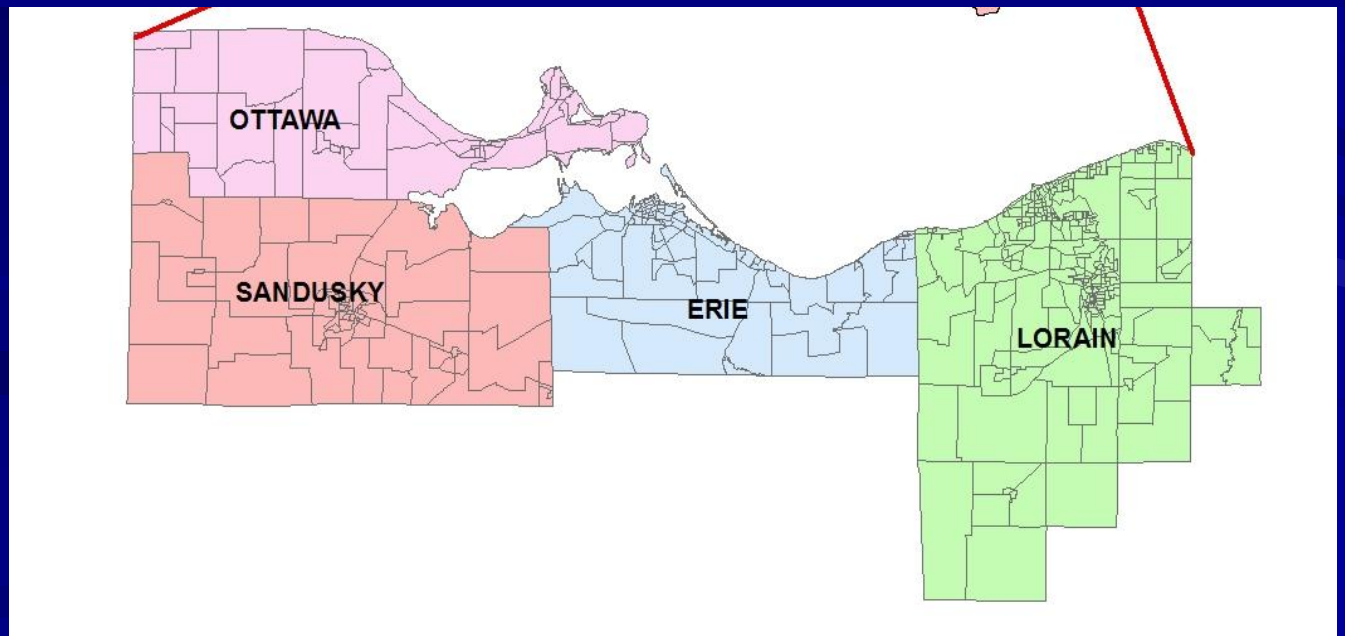
- First stage implementation
  - Allow effects to vary across housing submarkets, which allows for differences in implicit prices across the region
- Second stage
  - Statistical model of homeowner's demand for water quality across the region using the estimated implicit prices for water quality and substitute goods
  - For example:

$$\text{Secchi disk depth}_i = b_0 + b_1*(\text{Secchi implicit price}_i) + b_2*(\text{House size implicit price}_i) + \ldots$$

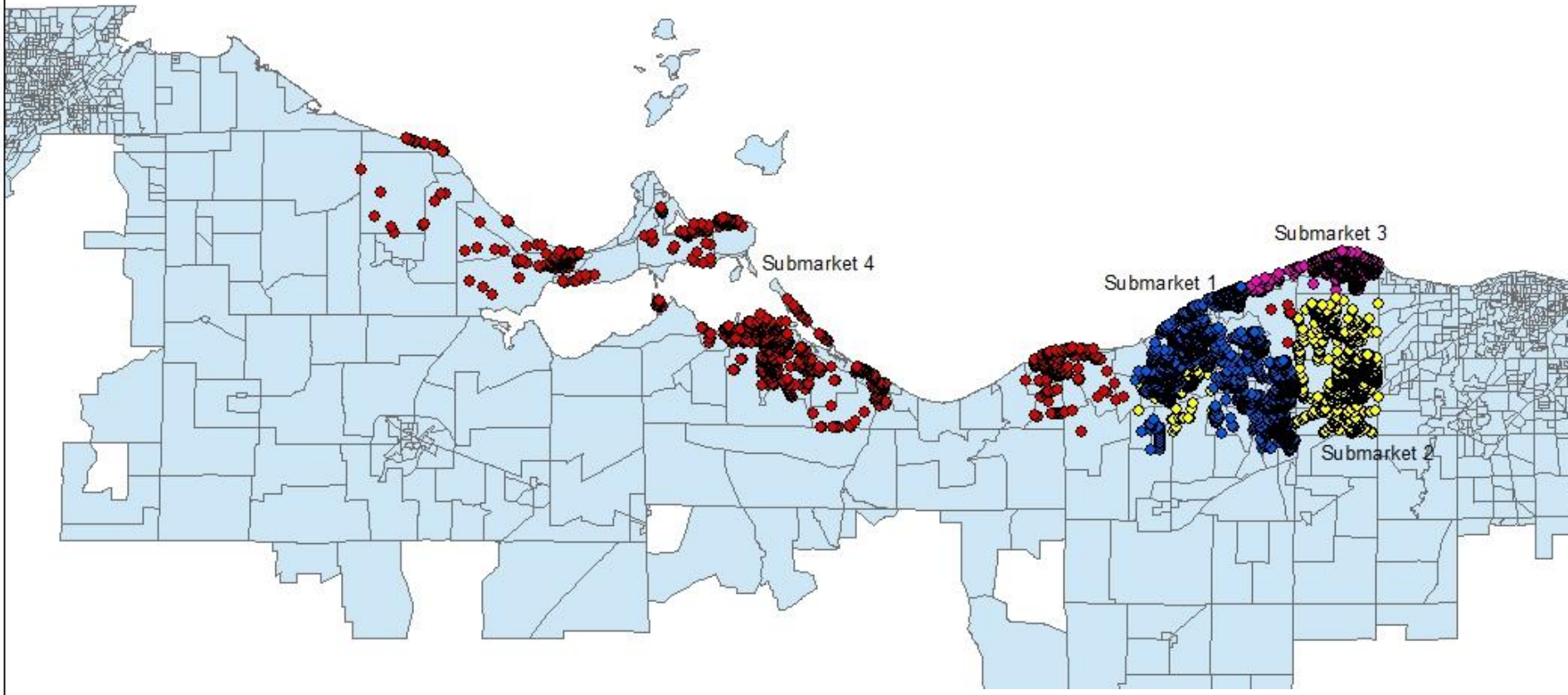
  - Use these results to estimate what households are **willing to pay** for improved water quality

Data

- Housing sales data 1991 – 1996 (10,665 observations from Erie, Lorain, Ottawa, Sandusky counties)
- Water quality data from ODNR, Ohio Sea Grant
- Other data from U.S. Census Bureau, OH Dept. Education; GIS used to calculate distance via roads

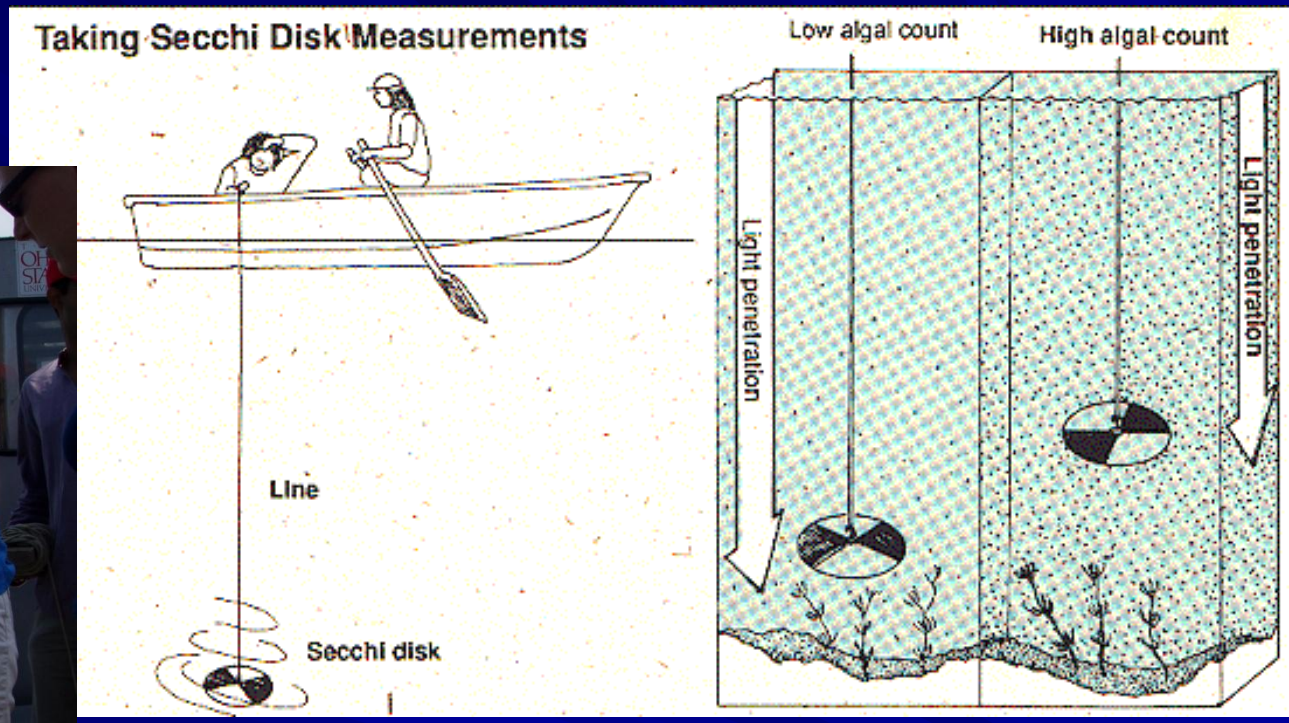


Housing Submarkets



- Submarkets were identified using cluster analysis methods to identify neighborhoods with similar geographic and economic characteristics

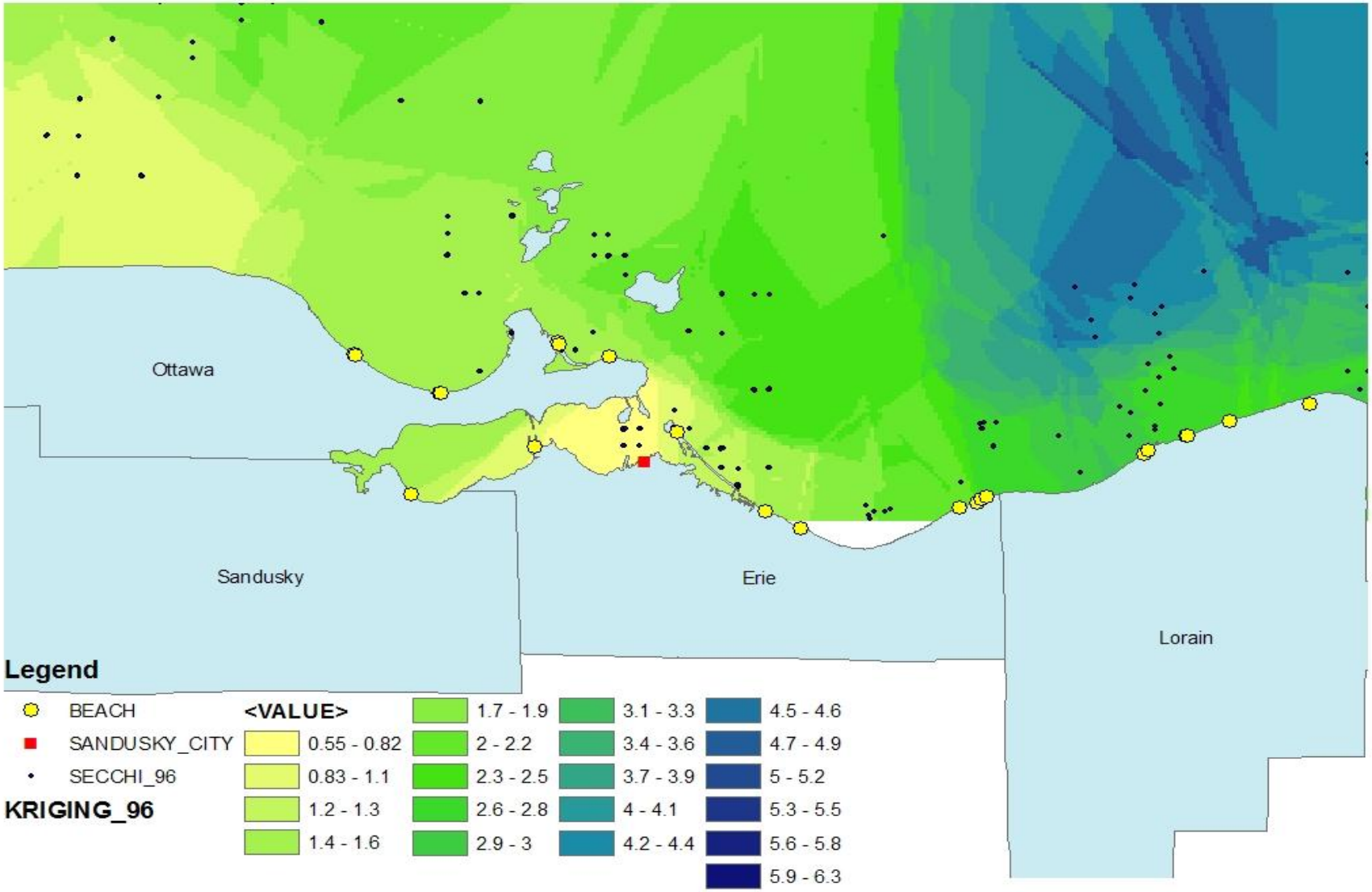
Measuring Water Clarity: Secchi Disk Depth



http://lakes.chebucto.org/DATA/PARAMETERS/SD/sd.html

http://www.ecy.wa.gov/programs/wq/plants/management/joysmanual/secchi.html

Water Clarity Data Interpolation



Selected Model Variables

	Submarket			
Variable Average	**1**	**2**	**3**	**4**
Housing price (1996 $)	95,755	119,105	176,869	108,372
Lot size (square meters)	286	579	388	392
House size (square feet)	1,525	1,751	2,104	1,530
Number of bathrooms	1.3	1.5	1.7	1.3
Age of house (years)	31	19	19	38
Presence of a deck (=1 if yes, 0 if no)	0.08	0.07	0.12	0.17
Presence of a fireplace (=1 if yes, 0 if no)	0.41	0.58	0.74	0.38
Driving distance to nearest beach (kilometers)	10.15	12.26	3.41	5.05
Fecal coliform (counts/100 mL) of nearest beach	257	279	370	201
Secchi disk depth (centimeters) of nearest beach	228	242	246	191

First Stage Selected Results: Marginal Implicit Prices

Marginal changes in water quality have a significant effect on housing prices, but effects differ by submarkets

	Submarket			
Variable	**1**	**2**	**3**	**4**
Lot size (tenth acre)	3,547	1,251	5,489	1,717
House size (square feet)	7	4	55	31
Number of bathrooms	7,102	9,933	15,453	11,027
Age of house (years)	-370	-799	-827	-383
Presence of a deck (=1 if yes, 0 if no)	6,535	8,820	16,002	7,255
Presence of a fireplace (=1 if yes, 0 if no)	8,346	9,786	15,899	10,289
Driving distance to nearest beach (kilometers)	242	-1,571	NS	-2,639
Fecal coliform (counts/100 mL) of nearest beach	NS	NS	-22	-13
Secchi disk depth (centimeters) of nearest beach	11	23	NS	100

Implicit prices calculated for mean house in each submarket

First Stage Selected Results: Marginal Implicit Prices

Testing for a threshold effect for "swimmability" of waters and an inflection point for water clarity:

	Submarket			
Variable	**1**	**2**	**3**	**4**
Mean fecal count ≥ 250 (= 1 if yes, 0 if no)	-4,360	NS	NS	-2,049
Mean fecal coliform (counts/100 mL)	10	NS	-11	-12
Mean secchi with inflection point (centimeters)	20	14	NS	95

Testing whether the influence of water clarity depends on the "swimmability" of waters:

	Submarket			
Variable	**1**	**2**	**3**	**4**
Marginal effect of secchi when mean fecal ≥ 250	+	+	NS	NS
Marginal effect of secchi when mean fecal < 250	+	NS	NS	+

Second Stage **Preliminary** Results: Mean Benefits to Homeowners from Improved Swimmability

	Target Fecal Level (/100ml)				
	350	**300**	**250**	**200**	**150**
Mean Benefits per Household ($)	2,915	3,308	4,242	5,807	8,216
% Affected Houses in Sample (actual level > target)	23	32	39	45	50

Actual fecal coliform count mean for region = 256/100 ml

Second Stage **Preliminary** Results: Mean Benefits to Homeowners from Improved Water Clarity

	Target Secchi Disk Depth (cm)			
	100	**150**	**200**	**230**
Mean Benefits per Household ($)	1,998	2,303	4,668	4,339
% Affected Houses in Sample (actual level < target)	1	16	41	61

Actual secchi disk depth mean for region = 221.3 cm

Conclusions

- Water quality of Lake Erie has significant effects on housing values and households are willing to pay for improved water quality.
- Preliminary results: mean benefits to homeowners in the Lake Erie study region from improvements in swimmable water (reductions in fecal coliform counts) and water clarity (increases in secchi disk depth) range from $2,000 – 8,000 per household depending on the scenario.
- This analysis captures only one type of value. Other values are also important for a full benefit-cost analysis.
- Unanswered questions: What improvements are realistic? What is the most efficient means of achieving them? What is the best way to raise public revenues to support efforts to improve water quality?