Hedonic Analysis of Lake Water Quality in Orange County, FL Utilizing a GIS Approach

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Outline of Presentation

- Overview of Study
  - Introduction to Hedonic Modeling
- Previous Studies
- Data Setting, Sources, and Compilation
- Data Modeling
  - Results
- Application

Overview of Study

- Why are we doing this study?
  - Estimate the effect of differential lake water quality on nearby property prices.
- How do we accomplish that?
  - Hedonic Modeling.
- What does that gain us?
  - Use the implied dollar amounts for lake water quality to estimate a lower bound for the benefits of introducing a clean water program.

Overview – Hedonic Modeling

- Hedonic modeling is a method of analyzing the characteristics of heterogeneous goods. It decomposes the item being researched (home sale price) into its constituent characteristics, and obtains estimates of the contributory value of each characteristic (bedrooms, bathrooms, lot size, lake water quality, distance to city center, etc).
- Used to calculate the Consumer Price Index; also for wages and cars.

Hedonic Analysis

Home Sale Price

- Bedrooms
- Bathrooms
- Square Footage
- Lot Size
- Lake Water Quality
- Distance to city center
- Golf Course Frontage
- Lake Frontage
- Canal Frontage
- Others…

Previous studies

- "The absence of hedonic studies dealing with water quality in the environmental economics literature is striking." – Legget and Bockstael (2000)
- Water Quality literature:
  - Steinnes (1992)Michael et al (1996)
  - Michael et al (2000) Legget and Bockstael (2000)
  - Poor et al (2001) Boyle and Taylor (2001)
  - Gibbs et al (2002) Krysel et al (2003)
- Lake Proximity Literature:
  - Brown and Pollakowski (1977)
  - Lansford and Jones (1995)
  - Palmquist and Fulcher (2006)

Non-Lakefront Homes

- Should we –
  - Assume that non-lakefront homes have no value?
  - Apply implicit prices obtained from lakefront properties to non-lakefront properties?

    →NO. Both approaches will result in substantial error.
- How to make it better –
  - Incorporate non-lakefront homes.
  - Implicit price of water quality varies over distance.

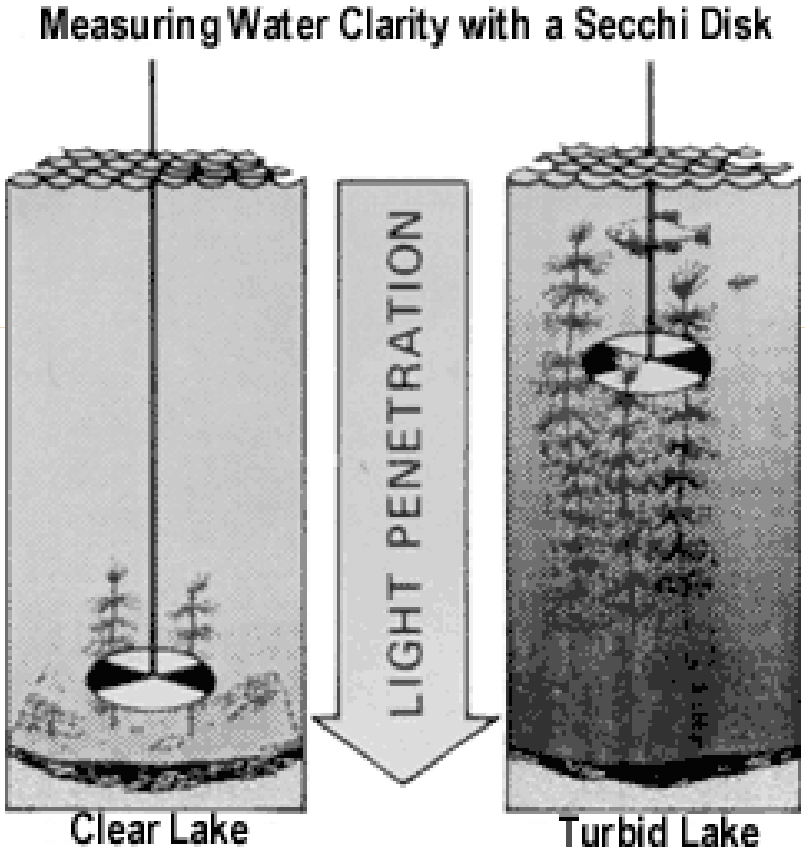
Setting

- Orange County, Florida
- 1990-2004
- 126 Lakes with Water Quality Measurements
- 77,158 Property Sales within 1000 meters of the measured lakes

Data Sources

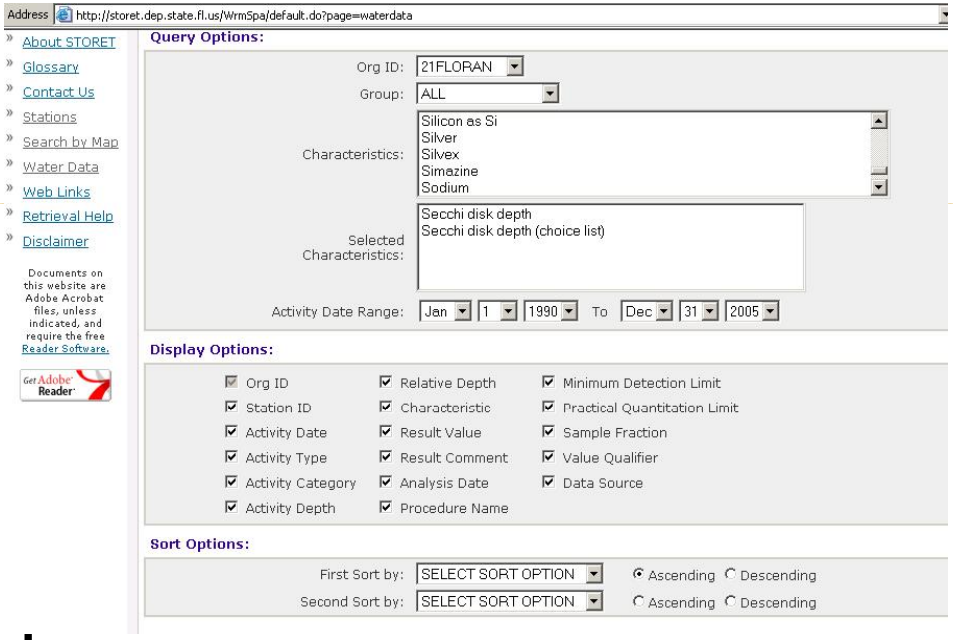
- Lake Water Quality Measures
  - Florida DEP STORET (STOrage/RETrieval) Website
  - Orange County's Environmental Protection Division Website
  - City of Winter Park, FL
  - City of Maitland, FL
  - City of Orlando, FL
- Parcel Specific Attributes
  - Orange County Property Appraiser
- Other
  - Federal Aviation Administration – Noise Zones
  - US Census – Demographic Information
  - Orange County– Lakes Layer

Secchi Disk – Our Quality Measure



Data Compilation

Water Information



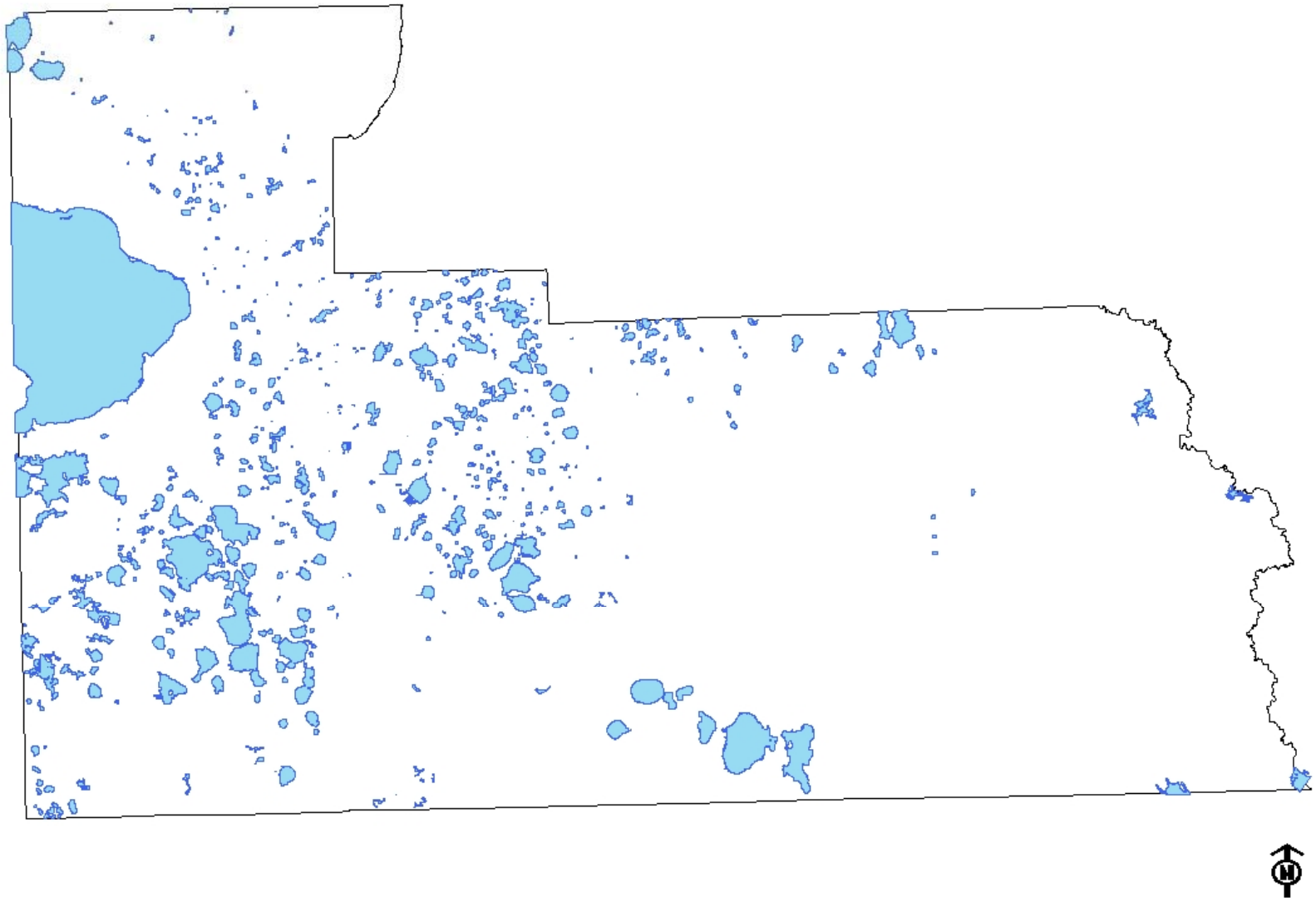
- Quality
  - STORET
  - Cities
- Shapes
  - County Lakes Layer
    - Propagating the 126 lakes of interest with metrics.

Data Compilation

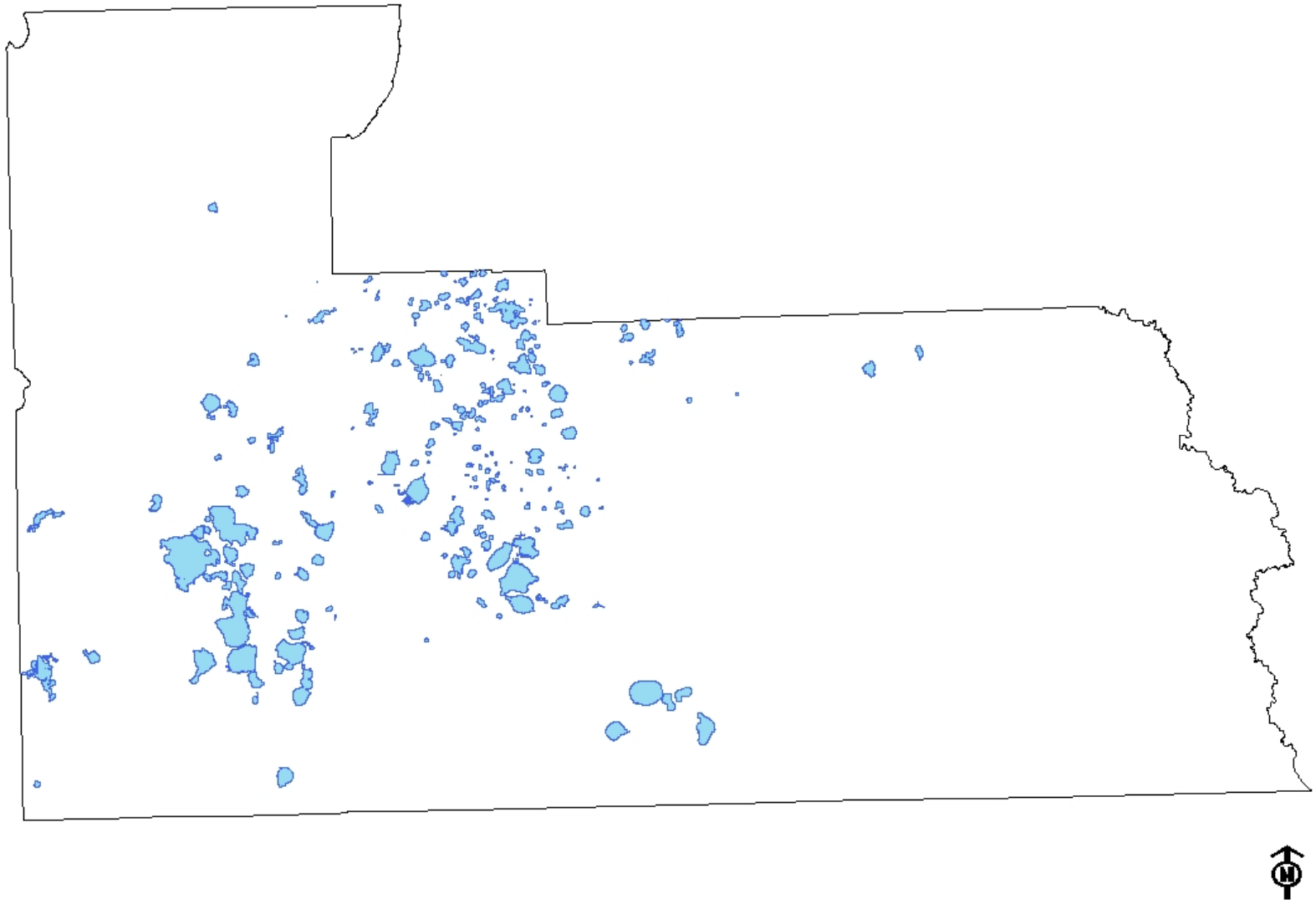
Orange County Property Appraiser

- Computer Aided Mass Appraisal (CAMA)
  - Parcel Specific Information Selected for Qualified and Improved Sales of Single Family Homes
  - Contains the last 5 sale prices and sale dates for each property.

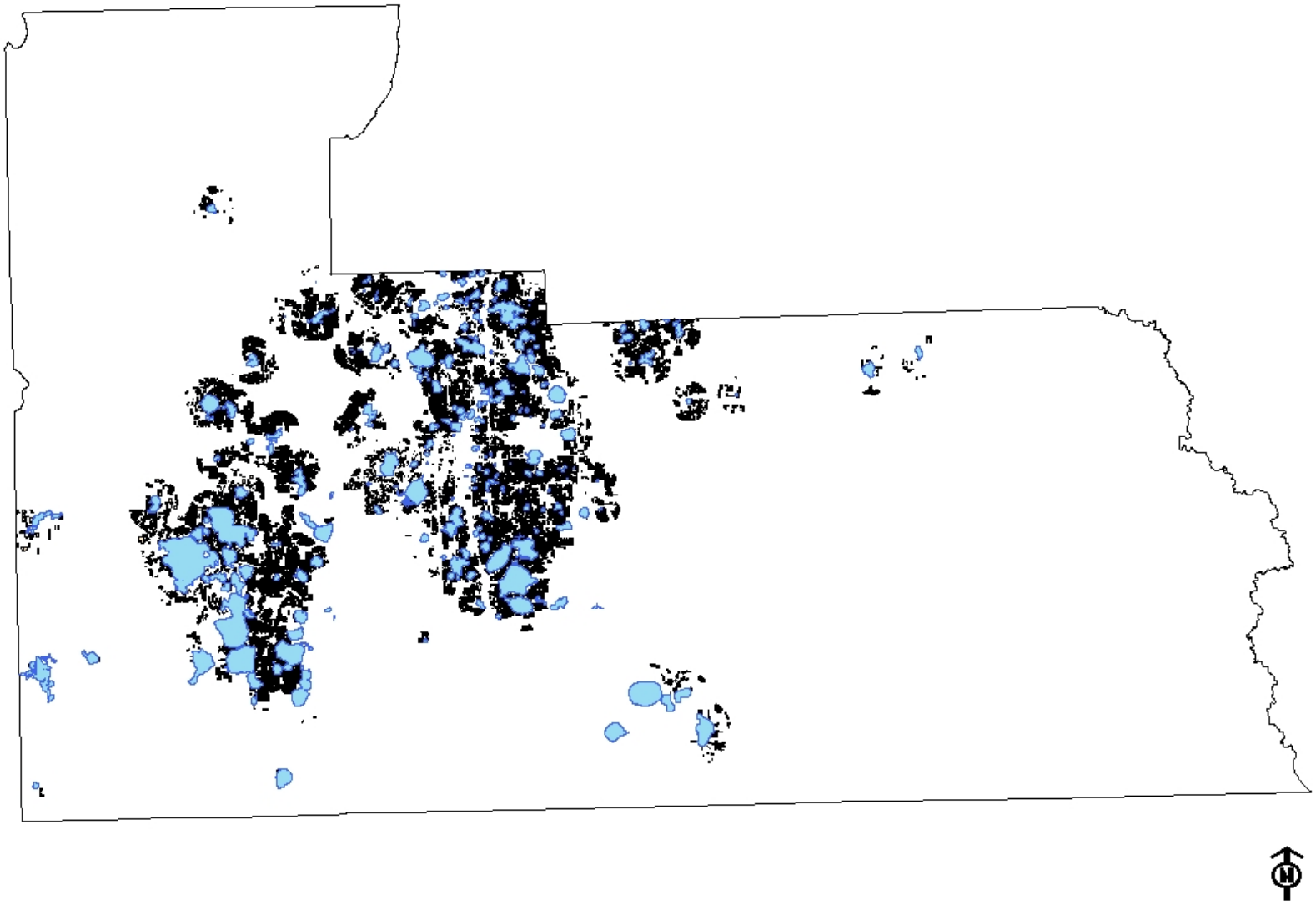
Orange County – 582 Lakes



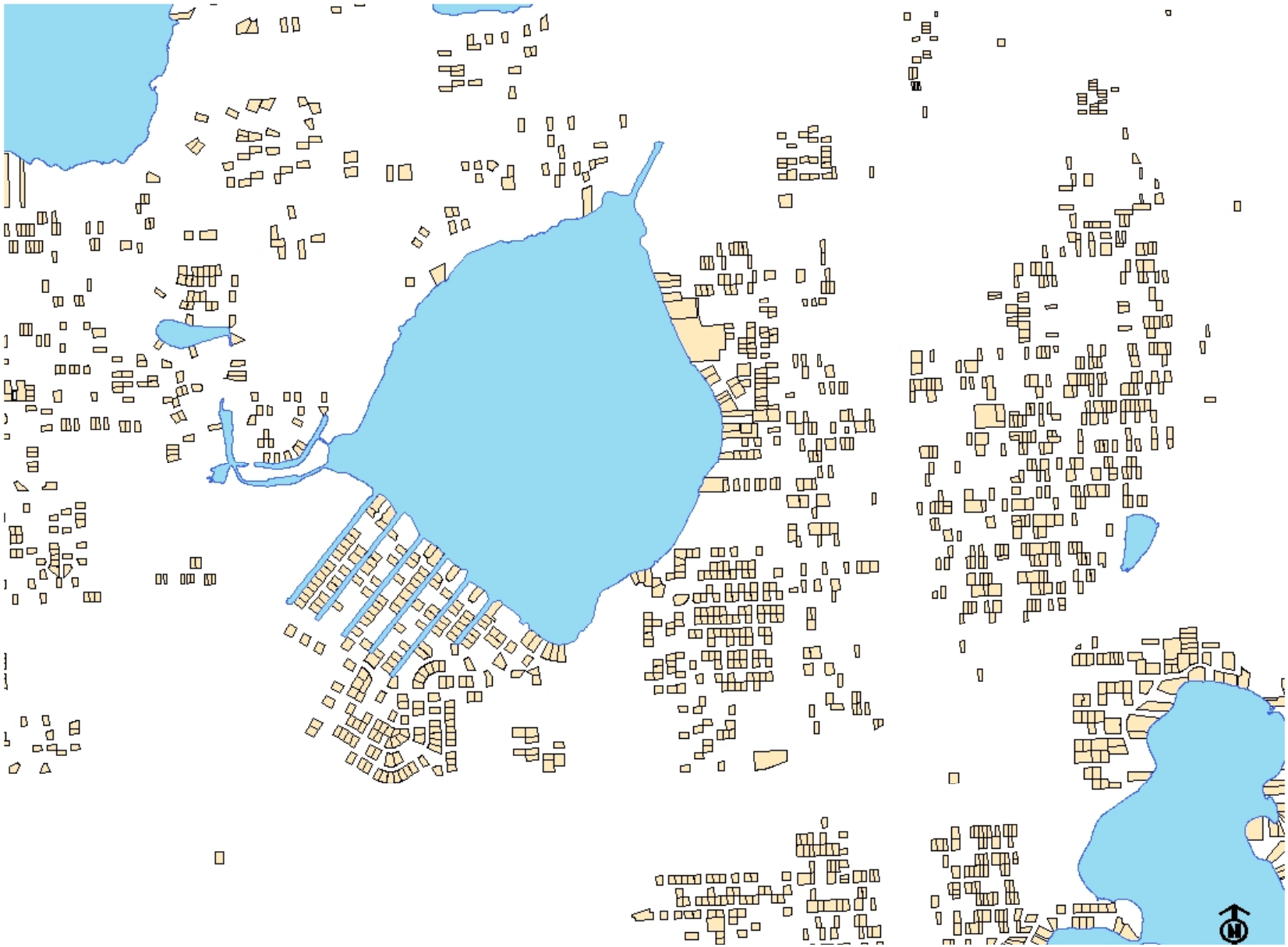
Orange County – 126 Lakes with Metrics



Qualified SFH Sales w/in 1000m



Closer View



Putting it all together…

- Each home sale has the following observations associated with it -

Sale Price =

Heated Area	Parcel Area	Population
Beds	Airport Noise Zone	White
Baths	Distance to Lake	Black
Date Built	Size of Lake	Hispanic
Sale Date	Secchi Disk Measure	Over 65
Parcel X Cord	Distance to Central Business District	
Parcel Y Cord	Median House Hold Income	
Pool	Time and lake indicator variables	

Model

$$\ln(P) = \beta_0 + \beta_1 \ln(SDM) + \beta_2 WF * \ln(SDM) + \beta_3 \ln(dist\_lake) * \ln(SDM) +$$

$$\beta_4 \ln(lake\_area) * \ln(SDM) + \beta_5 WF + \beta_6 \ln(dist\_lake) + \sum_{i=7}^{k} \beta_i z_i + \varepsilon$$

- z_i: characteristics of the home unrelated to water quality
- β_j, $j=0,\ldots,k$ to be estimated.
- Dual-Log form.
- Ordinary least squares regression
  - $\varepsilon \sim N(0,\sigma^2)$

Model 4S

- Spatial Error Model

$$\varepsilon = \lambda W \varepsilon + u$$

$$u \sim N(0, \sigma^2 I)$$

  - Maximum likelihood regression
    - traditional Ordinary Least Squares (OLS) model does not account for spatial dependence.
  - Lagrange Multiplier and Likelihood Ratio tests both indicate the presence of spatial dependence in the error.

Results

Table 1. Selected Hedonic Estimation Results

	OLS		Spatial	
Variable	$\hat{\beta}$	SE	$\hat{\beta}$	SE
Lakefront	0.182***	0.024	0.191***	0.017
Ln(Distance)	-0.039***	0.004	-0.064***	0.004
Ln(SDM)	-0.034	0.026	-0.015	0.025
Ln(SDM)*Lakefront Property	0.053***	0.014	0.035***	0.009
Ln(SDM)*Ln(Distance)	-0.012***	0.002	-0.007***	0.002
Ln(SDM)*Ln(Area Lake)	0.010***	0.001	0.005***	0.001
λ	---		0.746***	0.005
R^2	0.8957		0.9153	

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The full set of estimation results is reported in Appendix A. Also note that White's robust standard errors are used to control for heteroskedasticity.

Mean Implicit Prices

Table 2. Mean Implicit Prices

Scenario	Units	OLS	Spatial
Waterfront Premium	Waterfront vs Non-Waterfront	$109,963.40	$100,117.98
SDM: Waterfront	1 ft increase in SDM	$7,674.66 ($870.76)	$4,358.16
SDM: Non-Waterfront	1 ft increase in SDM	$787.26 ($112.40)	$335.89
Distance (Non-Waterfront)	1 m reduction in dist. to lake	$22.63	$28.64

Standard errors appear in parentheses. These implicit prices are evaluated at the sample means.

Implicit Prices and Distance

Table 3. SDM Implicit Price and Distance, Non-waterfront Homes*

	OLS		Spatial	
Distance to Lake (m)	SDM†	Distance‡	SDM†	Distance‡
100	$1,330.34	$104.85	$641.27	$132.71
300	$941.32	$34.95	$419.83	$44.24
500	$760.30	$20.97	$316.87	$26.54
700	$641.13	$14.98	$249.05	$13.23
900	$552.12	$11.65	$198.39	$14.75

*SDM implicit prices are for non-waterfront homes. The implicit prices are evaluated at the sample means

†The implicit price of increasing the SDM value by 1 foot at the given distance.

‡The implicit price of decreasing the distance to the nearest lake by 1 meter at the given distance.

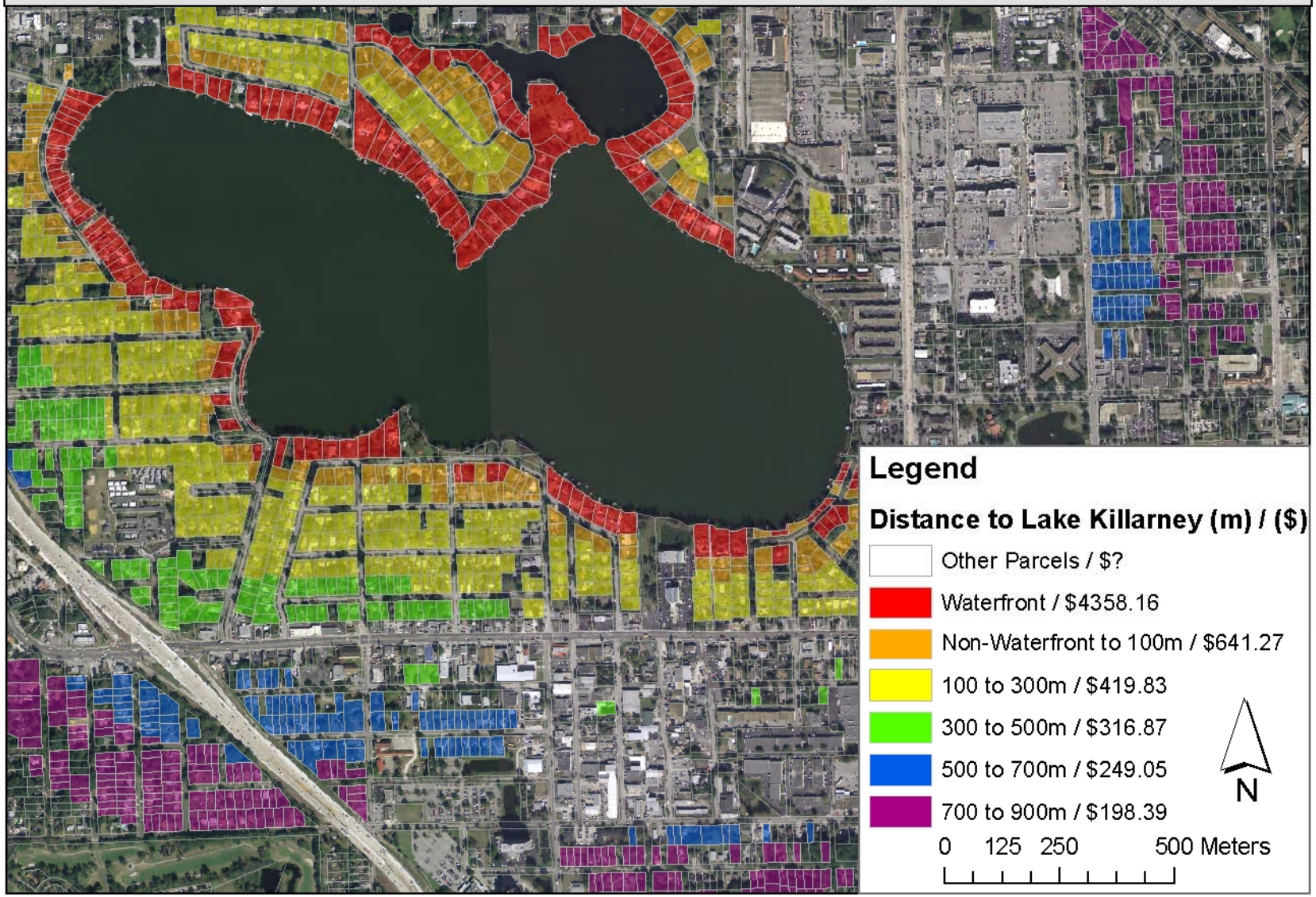
Conclusions

- Lakefront homes
  - Positive Values
- Non-lakefront homes
  - Positive values
  - Different values
  - Vary over distance

Applications

- Gradient Mapping of Benefits
- Calculate lower bound of a clean water program

Mean Implicit Price Increase to Single Family Homes by Increasing Secchi Disk Measure 1 Foot in Lake Killarney



Distance to Lake Killarney in Meters	Mean Implicit Price 1ft Increase in SDM of Lake Killarney	Tax Base Before	Tax Base After*	Tax Base Increase Associated with 1ft Increase in SDM
Waterfront	$4,358.16	$854,370	$866,706	$12,336
100	$641.27	$309,871	$311,456	$1,585
300	$419.83	$727,982	$731,262	$3,280
500	$316.87	$456,743	$458,363	$1,620
700	$249.05	$766,252	$768,398	$2,146
900	$198.39	$1,099,314	$1,101,898	$2,584

Total Tax Benefit*
$23,551

* This is a lower bound estimate.

Questions?

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Extras

- When Waterfront only regression is run:
  - Using model 4:
    - 2145 obs, R^2 = 0.8091
    - Implicit Price of SDM: $5,377.944
  - Using model 2:
    - 2154 obs, R^2 = 0.8090
    - Implicit Price of SDM: $5419.28

Summary Statistics:

Table 2. Summary Statistics on the Residential Property Characteristics:

Lakefront and Non-Lakefront Homes

		Lakefront (N =2,145)		Non-Lakefront (N =75,013)	
Variable Description	Units	Mean	Standard Deviation	Mean	Standard Deviation
Property Characteristics					
Sales Price	2002 Dollars	395,292.30	339,920.20	172,621.10	181,204.10
Heated Area	Square Feet	2,784.122	1,288.574	1,925.884	921.061
Area of Parcel	Square Meters	2,742.727	2,642.569	1,077.542	1,091.426
Number of Bedrooms	--	3.584	1.020	3.276	0.839
Number of Bathrooms	--	2.761	1.098	2.206	2.494
Home Age	Years	22.604	13.430	17.952	14.637
% With Pool	--	21.724	---	20.15	---
Spatial Characteristics					
Distance to Nearest Lake	Meters	---	---	463.347	265.955
Area of Nearest Lake	Square Meters	2,114,760	2,566,002	1,094,610	1,770,958
Distance to Central Business District	Meters	9,028.76	5,404.977	8,993.594	5,031.721
Latitudinal Coordinate	Degrees	654,558.7	7,744.198	653,559.8	7,832.194
Longitudinal Coordinate	Degrees	505,232.4	6,723.287	505,718.8	6,067.607

Summary Stats …continued

		Lakefront (N =2,145)		Non-Lakefront (N =75,013)	
Variable Description	Units	Mean	Standard Deviation	Mean	Standard Deviation
Census Block Characteristics					
% of Population White	--	88.93	--	78.16	--
% of Population Black	--	4.52	--	12.18	--
% of Population > 65 Years of Age	--	15.09	--	11.33	--
Median Household Income	2000 Dollars	65,246.33	28,871.42	55,966.54	23,525.28
Distribution of Sales by Year					
% of Sales in 1990-1994	--	23.68	--	23.48	--
% of Sales in 1995-1999	--	40.05	--	37.81	--
% of Sales in 2001-2005	--	36.27	--	38.70	--

Marginal Implicit Prices

$$\frac{\partial P}{\partial SDM} = \beta_1\left(\frac{\bar{P}}{\bar{S}\bar{D}\bar{M}}\right) + \beta_2 * WF\left(\frac{\bar{P}}{\bar{S}\bar{D}\bar{M}}\right) + \beta_3 * \ln(dist)\left(\frac{\bar{P}}{\bar{S}\bar{D}\bar{M}}\right) + \beta_4 * \ln(acres)\left(\frac{\bar{P}}{\bar{S}\bar{D}\bar{M}}\right)$$

$$\frac{\partial P}{\partial SDM} = \left(\frac{\bar{P}}{\bar{S}\bar{D}\bar{M}}\right)[\beta_1 + \beta_2 * WF + \beta_3 * \ln(dist) + \beta_4 * \ln(acres)]$$

Which would you rather?