A Hedonic Analysis of Water Quality and the Chesapeake Bay TMDL

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Disclaimer: The views presented here do not necessarily represent the views of the EPA.

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Chesapeake Bay

- Largest estuary in the US
- Drainage basin covers 6 states: NY, PA, DE, MD, VA, WV, as well as DC
- Watershed home to more than 17 million people

Chesapeake Bay Pollution

- Site of one of the planet's first recognized "dead zones"
  - Fish kills and other problems
  - Estimated to now kill thousands of tons of clams, fish, and worms annually
- Large nutrient inputs cause a range of issues, including algal blooms, toxic algae, poor water quality.
  - Each year, roughly 300 million lbs of nitrogen reaches the Bay, about six times the amount in the 1600's.
- Colonial times – estimated 200,000 acres of oyster reefs. Today only 36,000.
- Estimated 100,000 new residents in the watershed each year.

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Chesapeake Bay TMDL

- Extensive restoration efforts over last 25 years
  - Insufficient progress
  - Continued poor water quality
  - PA, NY Farming inputs.
- Dec 29, 2010: Chesapeake Bay Total Maximum Daily Load (TMDL) – historic and comprehensive “pollution diet”.
  - Specifically, the TMDL sets Bay nitrogen (25%), phosphorus (24%) sediment (20%) reductions.
- “Novelty”: comprehensive involvement of all state actors in the watershed
  - Using extensive modeling tools and planning coordinated by EPA

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Chesapeake Bay TMDL Valuation

- In 2011, EPA committed to an assessment of the benefits and costs of the TMDL.
- NCEE, and Chesapeake Bay Program Office (CBPO).
  - SP Survey
  - Commercial and recreational fishing
  - Air Quality Impacts
  - Property price benefits
  - Dredging and several other categories
  - Costs

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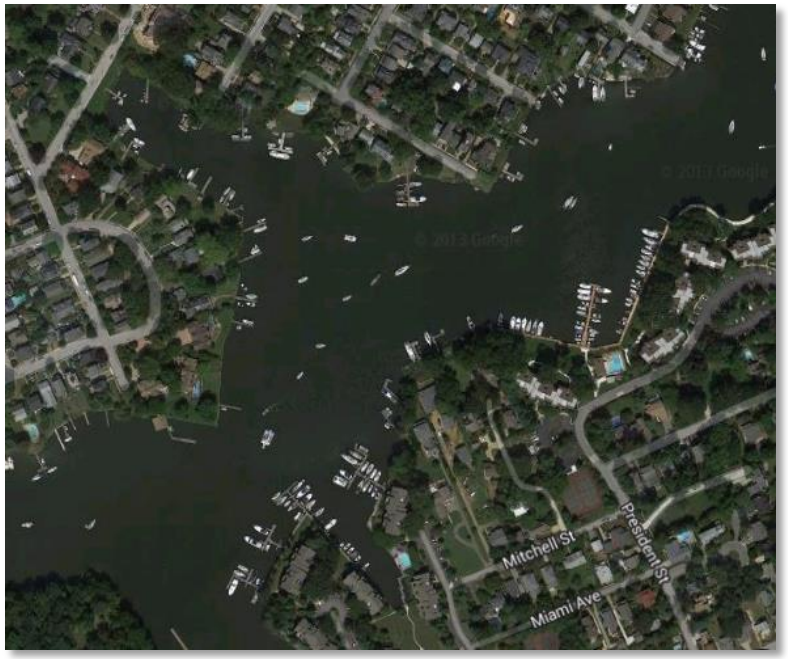
Property Prices

- Recreational and aesthetic improvements from the TMDL may be reflected in nearby property prices.
- Hedonic analysis of water quality in 14 MD counties
- Peer Review
  - Input from three academics with experience in hedonics of water quality/ecosystem services/coastal resources.



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Hedonic Water Quality Literature

- Literature is somewhat thin, particularly compared to air quality
- Majority from the northeastern US, in Lakes
  - Three recent studies in Florida, one on a Bay/Lagoon (Bin and Czajkowski).
- Chesapeake Bay – Leggett and Bockstael (2000), Poor et al. (2007)
- Multiple water quality indicators have been used
  - Oil content, turbidity (Feenberg and Mills, 1980) Fecal Coliform (Leggett and Bockstael, 2000), survey responses (Michael et al., 2000), Inorganic Nitrogen (Poor et al., 2007), TN, TP, CH (Walsh et al., 2011) "Location grade" (Bin and Czajkowski, 2013), several others.

- Water clarity is the most prevalent in the literature
  - Michael et al (1996), Boyle et al (1999), Boyle and Taylor (1999), Gibbs et al (2002), Krysel et al (2003), Walsh et al. (2011), Zhang V Tech Dissertation
  - Easily perceived, usually good representation of "quality."
- Majority of studies find a significant relationship between water quality and home prices.

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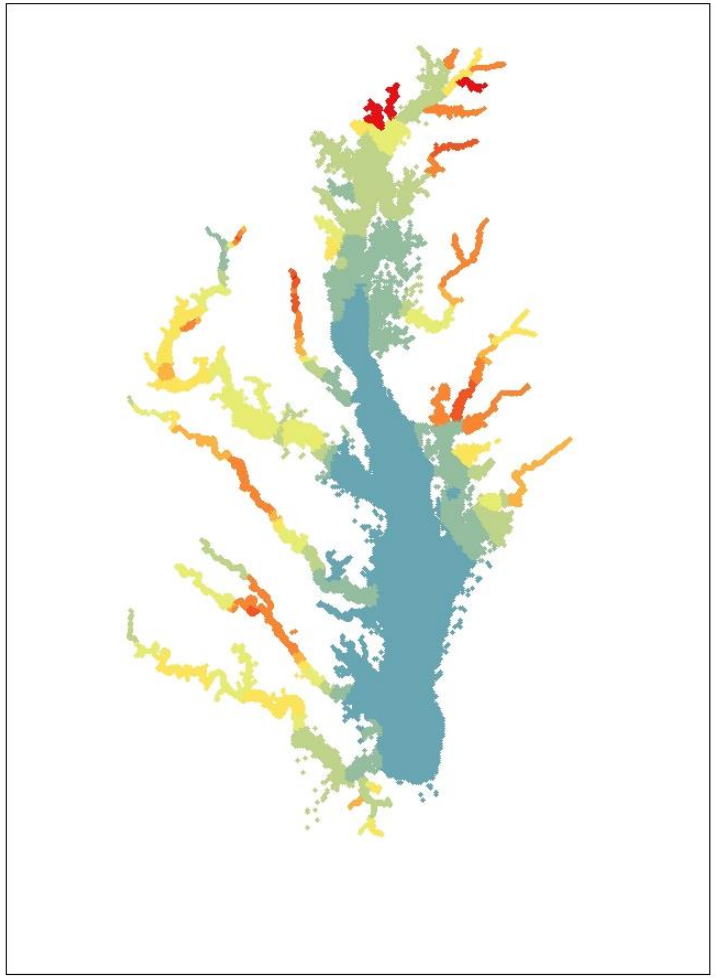
Water Quality Indicator

- Select K_D, the light attenuation coefficient
  - Clarity: K_D=1.45/SDM
  - Good historical data
  - CBPO's water quality model: project scenarios
    - TMDL vs baseline

- Chesapeake Bay has water quality criteria for clarity.
  - SP survey

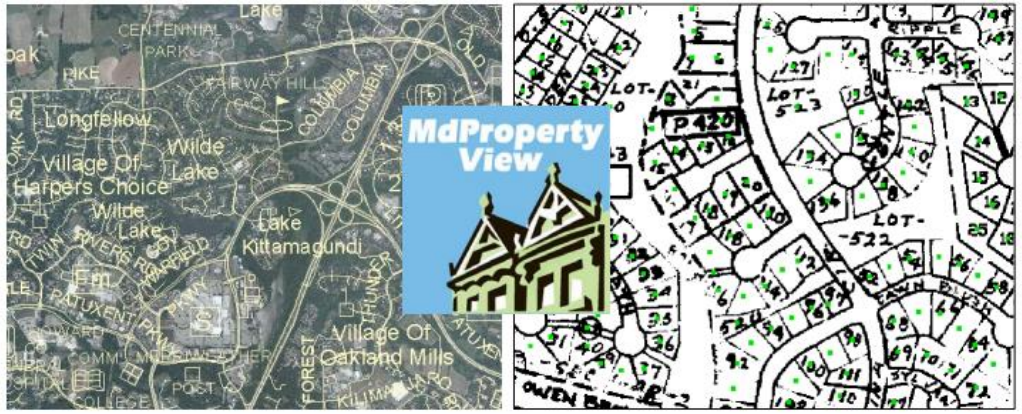
1991-2000

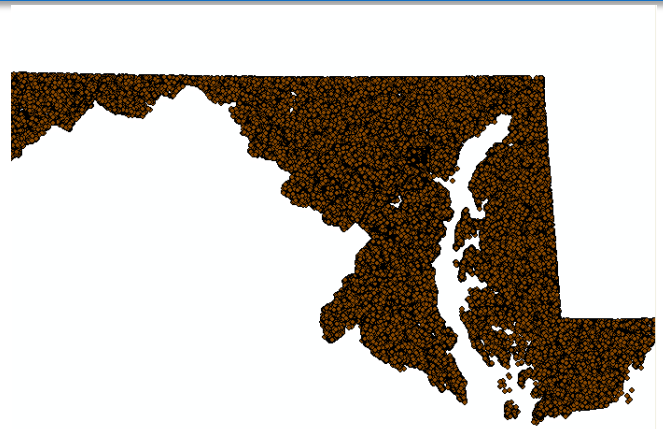


Data

- 14 Maryland Counties

Property Data

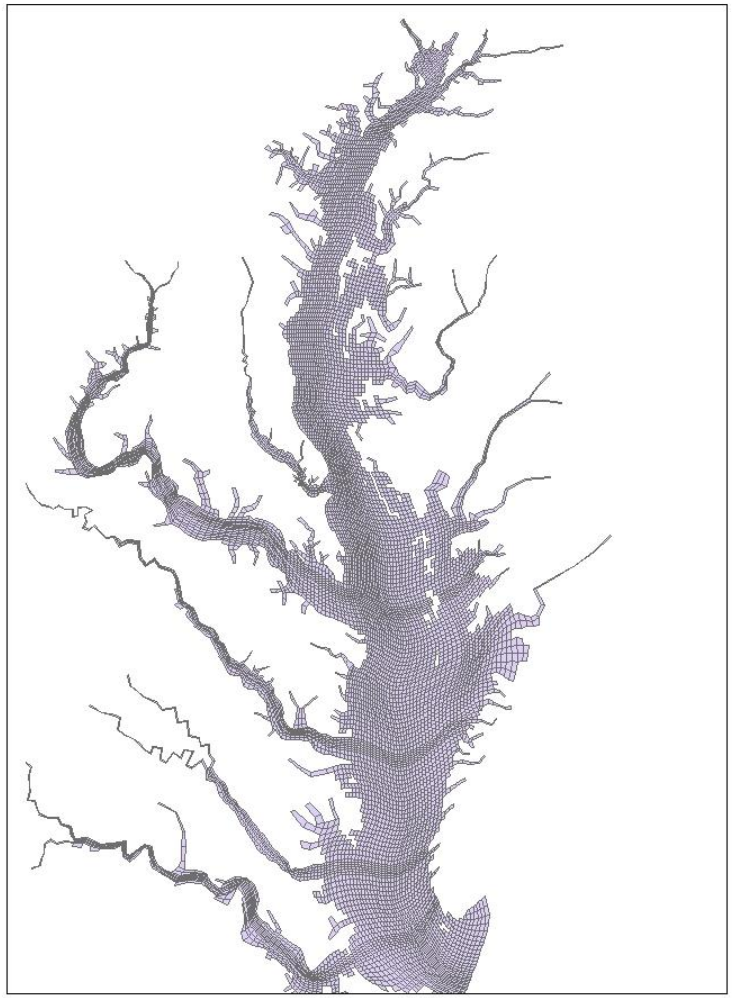




- Full set of parcels/sales from 1996-2008 from MD PropertyView
- GIS Maps
  - Census, waterbodies, zoning, open space

Data

- Water Quality
  - Interpolate historical data from monitoring stations
    - CBPO – WQ -> Interpolator cells
      - Approximately 1 km X 1 km
- GIS, Census data
  - High or medium density area, forest, etc
  - Open space, ag., wetlands, beaches
  - Dist to primary road, dist to nearest beach
  - Dist to DC or Baltimore
  - Block Group socioeconomic characteristics
  - In Nuclear Evacuation Zone.
  - Within 2 miles of power plant.



Methods

- Distance buffers

$$\ln(P) = \beta_0 + \beta_{WF} * WF + \beta_{WF_2} \ln(WQ) * WF + \sum \beta_{Di} \ln(WQ_i) * Dist_i +$$

$$\boldsymbol{\beta_{D_2} * Dist + \beta_H * H + \beta_L * L + \beta_T * T + \varepsilon}$$

  - WF, 0-500, 500-1000,1000-1500, 1500-2000
- Regressions estimated for each county
  - Separate markets

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… Other Alternatives

- Several others, some later explored in Meta-analysis.
  - Water quality not logged
  - 3 year water quality average, logged and not logged
  - Depth variable
  - Chlorophyll

Spatial Models

- Spatial dependence
  - Spatially correlated unobserved influences
  - Can cause bias or inconsistency in the estimated coefficients.
- Spatial Weights Matrix
  - Exogenously specify the neighborhood.
    - Nearest neighbor, Inverse Distance
      - Comparable sales
- General Spatial Model:
- . $y = \rho W_1 y + X\beta + \varepsilon,\ \varepsilon = \lambda W_2 \varepsilon + u$

Individual Condominium Unit Appraisal Report File # 11182

There are 6 comparable properties currently offered for sale in the subject neighborhood ranging in price from $ 215,000 to $ 375,000

There are 18 comparable sales in the subject neighborhood within the past twelve months ranging in sale price from $ 195,000 to $ 344,000

SALES COMPARISON APPROACH

FEATURE	SUBJECT	COMPARABLE SALE # 1		COMPARABLE SALE # 2		COMPARABLE SALE # 3	
Address and Unit #	2118 Bucknell Terrace 34	2202 Bucknell Terrace 34		10737 Bucknell Drive 8		10821 Bucknell Drive 29	
Project Name and Phase	Wheaton Towne 2 1	Wheaton Towne 1		Wheaton Square East		Wheaton Square East 1	
Proximity to Subject		0.07 miles W		0.19 miles SE		0.15 miles S	
Sale Price	$ 340,000		$ 344,000		$ 315,500		$ 290,000
Sale Price/Gross Liv. Area	$ 219.07 sq. ft.	$ 221.65 sq. ft.		$ 224.08 sq. ft.		$ 205.97 sq. ft.	
Data Source(s)		MLS/Agent LP: $348,900		MLS/Visual LP: $329,900		MLS/Visual LP: $299,500	
Verification Source(s)		Public Records DOM: 14		Public Records DOM: 19		Public Records DOM: 223	
VALUE ADJUSTMENTS	DESCRIPTION	DESCRIPTION	+(-) $ Adjustment	DESCRIPTION	+(-) $ Adjustment	DESCRIPTION	+(-) $ Adjustment
Sales or Financing Concessions		Conv @ Mkt none noted		Conv @ Mkt $5,500 C.C.	0	Conv @ Mkt 8,600 C.C.	0
Date of Sale/Time		C1/11S3/11		C3/10S5/10	0	C6/10S8/10	0
Location	Wheaton Towne	Wheaton Towne	0	Wheaton SQ	0	Wheaton SQ	0
Leasehold/Fee Simple	Fee Simple	Fee Simple		Fee Simple		Fee Simple	
HOA Mo. Assessment	$100	$130		$223		$202	
Common Elements and Rec. Facilities	Common area	Common area		Common area		Common area	
Floor Location	INT TH	INT TH		End TH	-10,000	INT TH	
View	Other TH	Other TH		Other TH		Other TH	
Design (Style)	Townhouse	Townhouse		Townhouse		Townhouse	
Quality of Construction	Brick	Brick		Brick		Brick	
Actual Age	1967 YB	1967 YB		1968 YB		1968 YB	
Condition	Good	Good/new reno	-10,000	Good		Good	
Above Grade Room Count	Total 6 Bdrms. 3 Baths 2.5	Total 6 Bdrms. 3 Baths 2.5		Total 6 Bdrms. 3 Baths 2.5		Total 6 Bdrms. 3 Baths 2.5	
Gross Living Area	1,552 sq. ft.	1,552 sq. ft.	0	1,408 sq. ft.	+10,800	1,408 sq. ft.	+10,800
Basement & Finished Rooms Below Grade	760sf RR,HB	760sf RR,HB		704sf RR	+5,000	704sf RR	+5,000
Functional Utility	Average	Average		Average		Average	
Heating/Cooling	FWA/CAC	FWA/CAC		FWA/CAC		FWA/CAC	
Energy Efficient Items	Standard	Standard		Standard		Standard	
Garage/Carport	Off street park	Off street park		Off street park		Off street park	
Porch/Patio/Deck	Patio	Patio		Patio		Patio	
Fireplaces	2 fireplaces	2 fireplaces		no fireplaces	+5,000	no fireplaces	+5,000
Kitchen	Updated Kit	New Mod Kit	-10,000	Updated Kit		Full Mod Kit	+10,000
Net Adjustment (Total)		☐ + ☒ -	$ -20,000	☒ + ☐ -	$ 10,800	☒ + ☐ -	$ 30,800
Adjusted Sale Price of Comparables		Net Adj. 5.8 % Gross Adj. 5.8 %	$ 324,000	Net Adj. 3.4 % Gross Adj. 9.8 %	$ 326,300	Net Adj. 10.6 % Gross Adj. 10.6 %	$ 320,800

Summary of Sales Comparison Approach: Due to the paucity of recent sales of condominium townhouses in the subject's Wheaton market area, the comparables utilized are considered the best available. Comparable #1 was purchased as a foreclosure 10/2010, renovated and place back on the market. The townhouse was listed 1/15/2011 and contract in 14 days. According to the listing agent, the investor/contractor spent approximately $55,000 renovating the comparable. Comparable #1 offered new more expensive kitchen and bathrooms than the subject. Comparable #1 is located in competing Wheaton Towne Section 1 project. Comparable #2 was an updated end of group unit listed 3/12/2010. Comparable #3 was originally listed 3/17/2010 for $324,900. Comparables #1, #2 and #3 are the three highest price sales in the past 12 months of condominium townhouses in 20902 zip code that are over 10 years old.

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Table of Results

	Bayfront	0-500 meters	500-1000 meters
Anne Arundel	-0.126***	-0.023***	-0.009
Baltimore County	-0.090***	0.009	-0.015*
Calvert	-0.033*	0.001	0.021*
Cecil	0.010	-0.001	0.003
Charles	-0.058	-0.056**	-0.107***
Dorchester	-0.078*	-0.008	-0.013295
Harford	-0.096***	0.001	0.012
Kent	-0.142***	0.008	0.002
Prince Georges	-0.062	-0.001	0.022**
Queen Annes	0.017	-0.060***	-0.068***
Somerset	-0.091	-0.055	-0.141***
St Marys	0.014	-0.015	0.017
Talbot	-0.156***	-0.014	-0.031
Wicomico	0.046	-0.015	-0.010

*** p<0.01, ** p<0.05, * p<0.1

Overall results

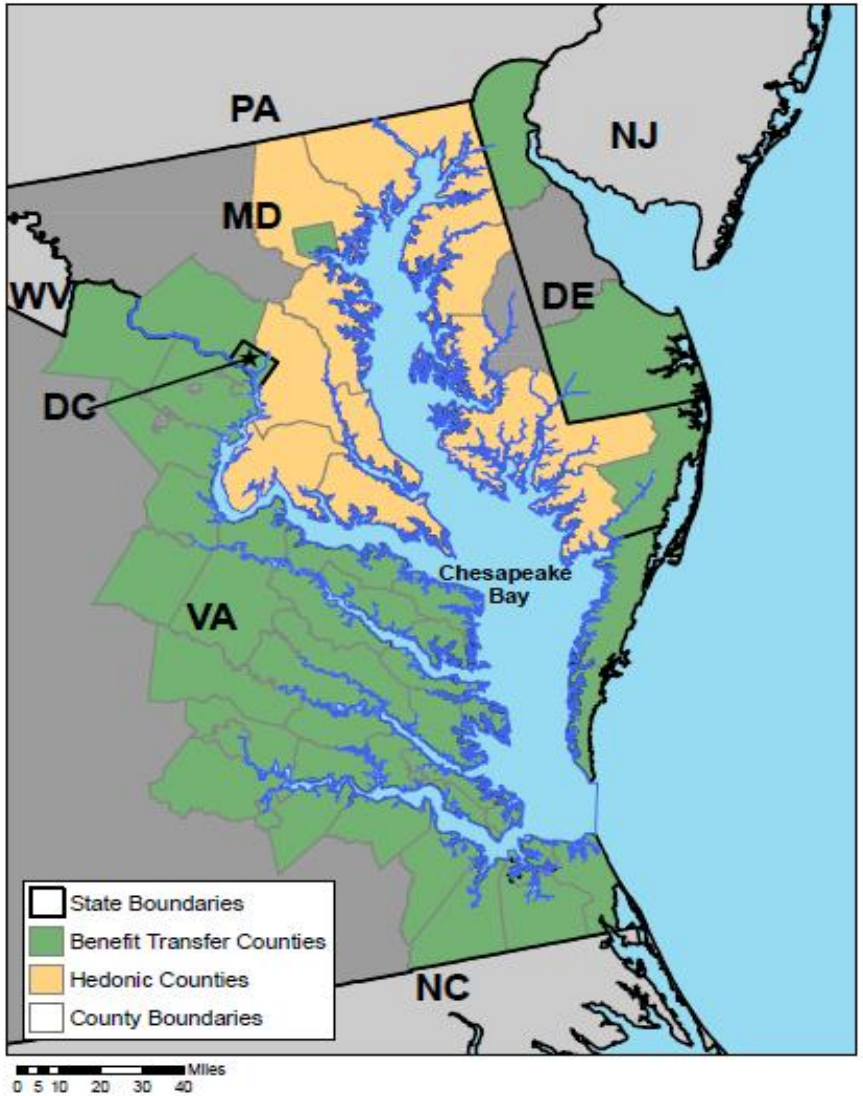
- Across the 14 counties:
  - 10 of 14 have negative waterfront coefficient
    - K_D and clarity inversely related
    - 7 of which are significant
  - None of the positive waterfront coefficients are significant
  - Mixed results beyond the waterfront
    - Evidence of impacts extending out past 500m in some counties.

Temporal Consistency?

- Length of data – questions about temporal consistency of estimates
- Identified several time demarcations to split the data
  - Run regressions on:
    - 1996-2001
    - 1996-2005
    - 2002-2008
    - 2002-2005
    - 2006-2008
- Results were mostly consistent across specifications, with minor differences in magnitude
  - Main difference: 2006-2008 data.
    - Larger variation in magnitude of the implicit prices.
    - However, when full model compared to 1996-2005, adding 2006-2008 did not appreciably change results.

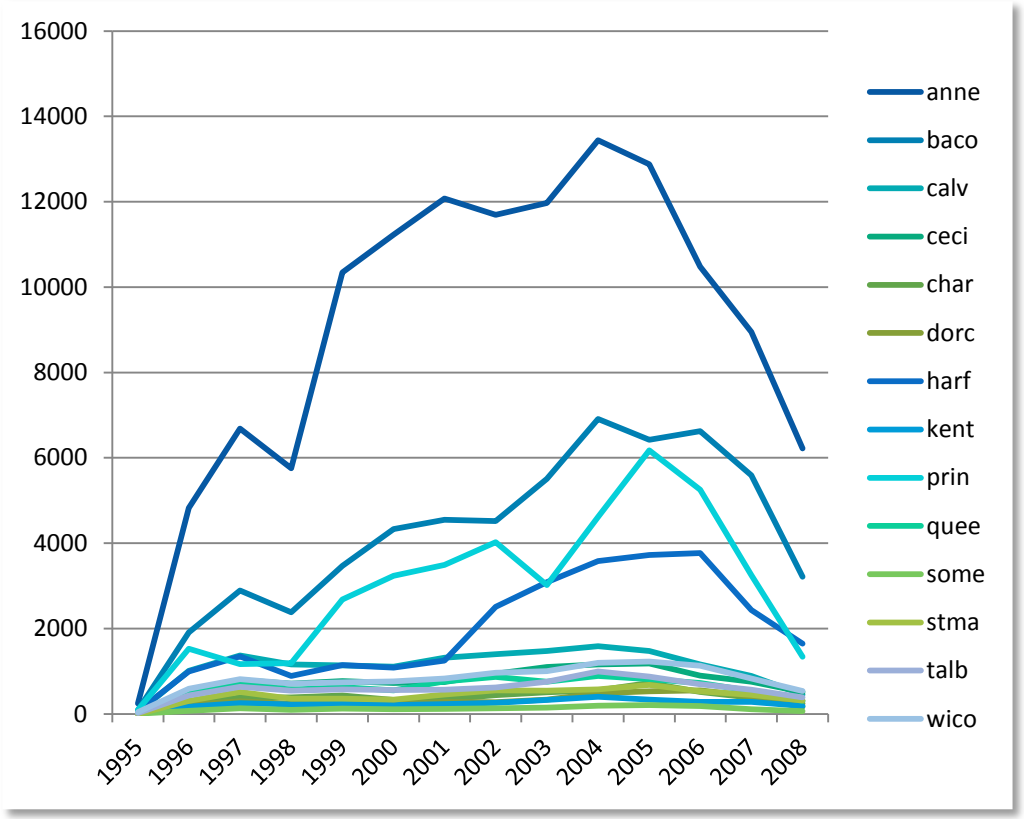
Other Project Components

- Meta-analysis of 14 Counties, specifications

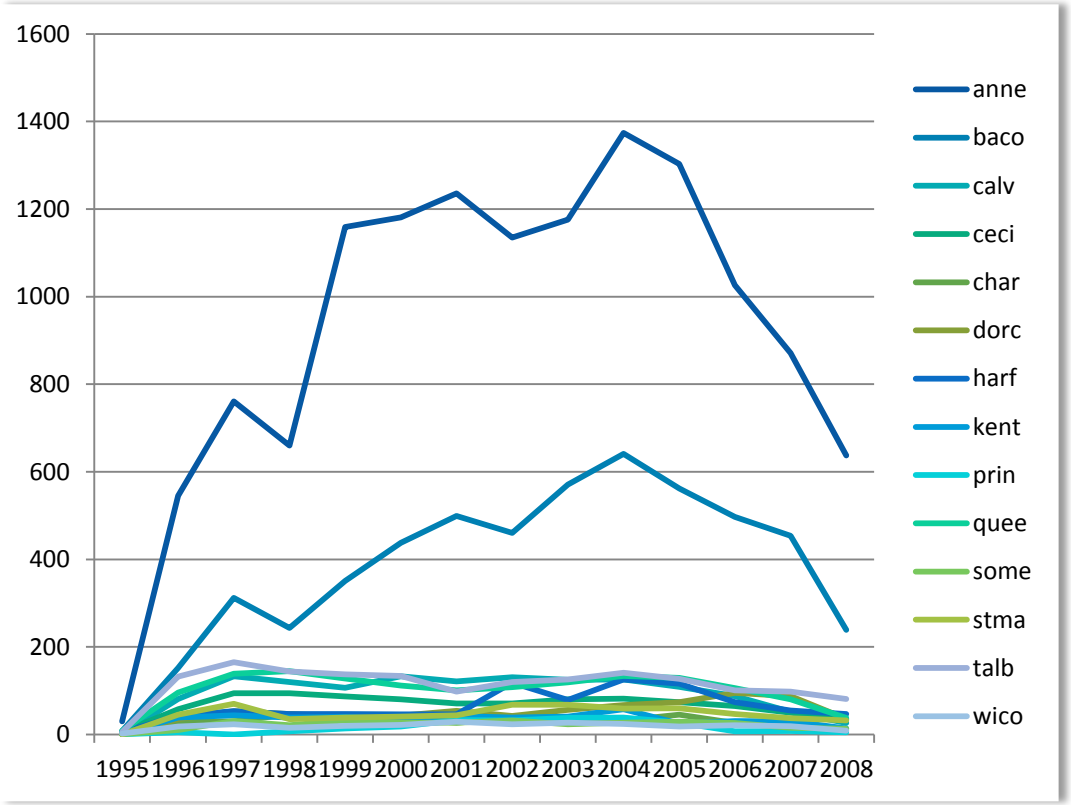


Appendix 1: Sales over time

- Total # of Sales



Total # of WF sales



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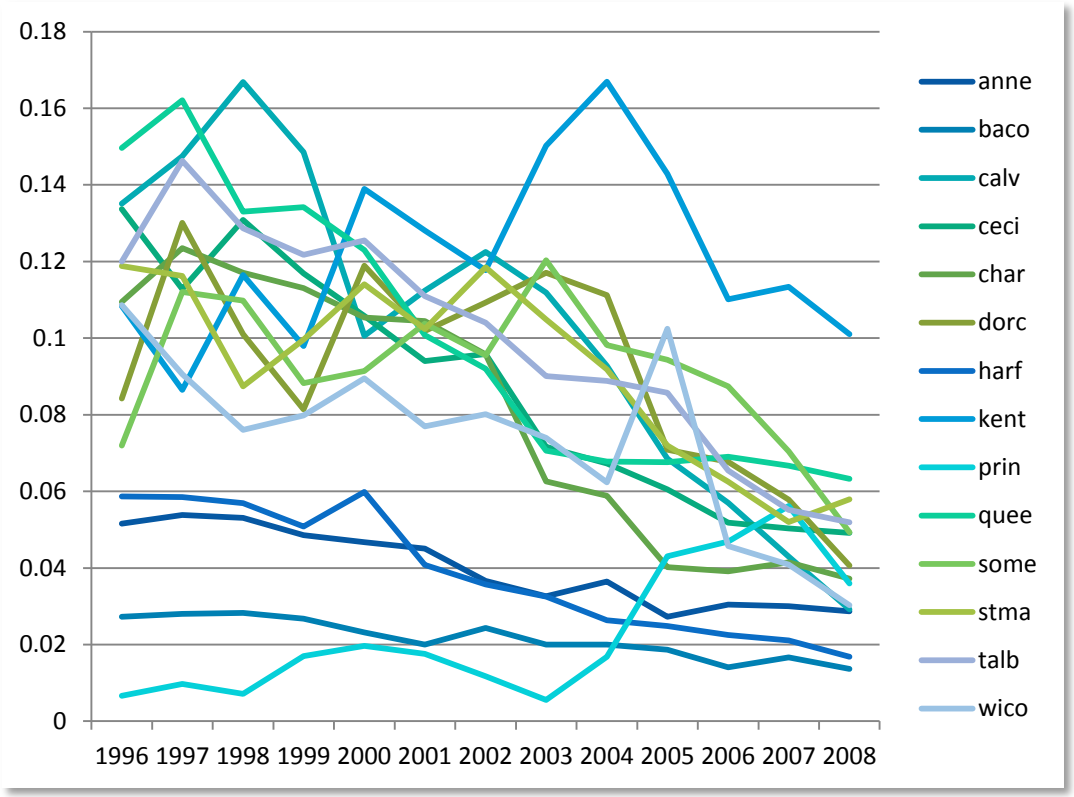
- Percent of Vacant Sales across Counties