

# An Urban Single Family Housing Valuation Case Study: Arlington, Virginia.

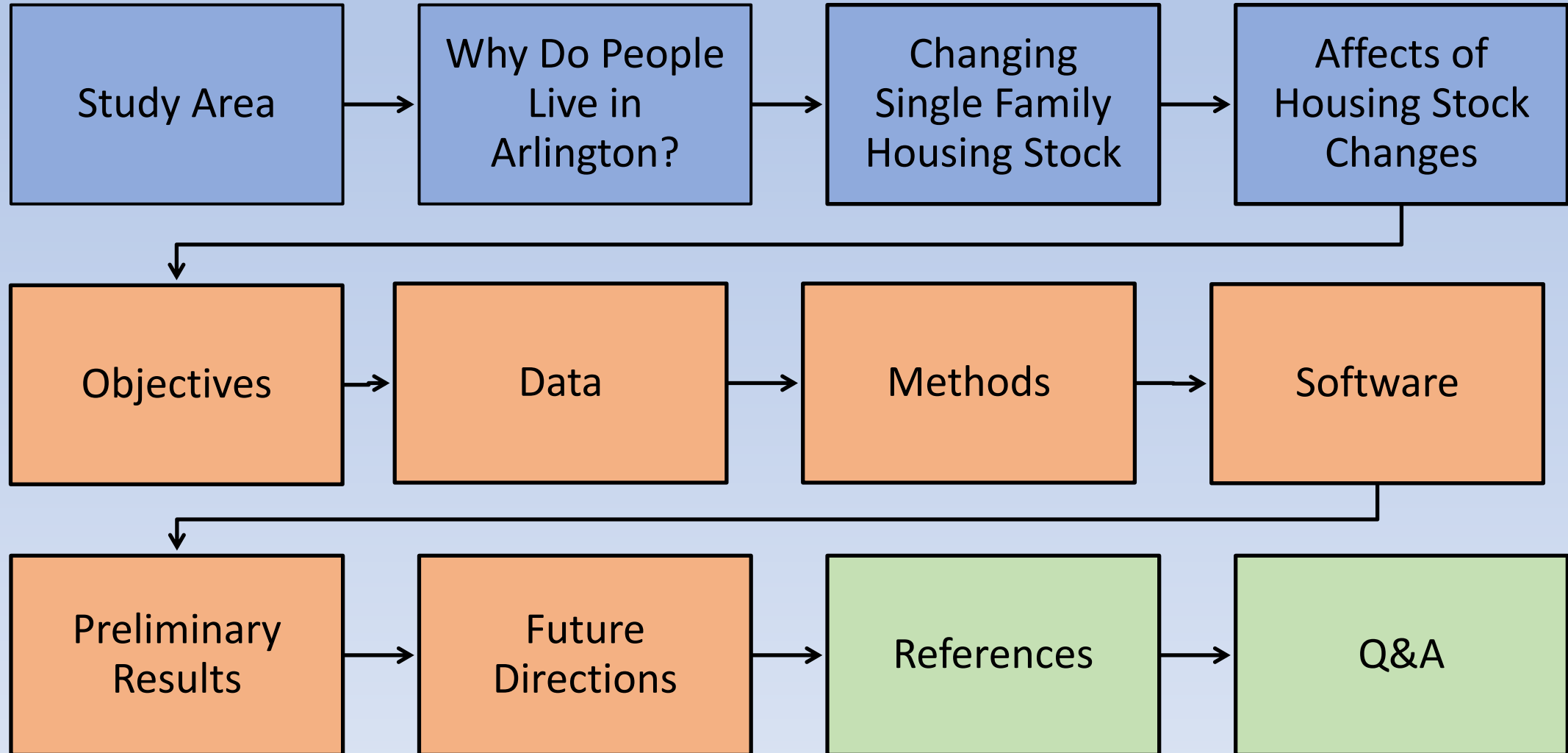
*With application to housing affordability and demographic analysis*

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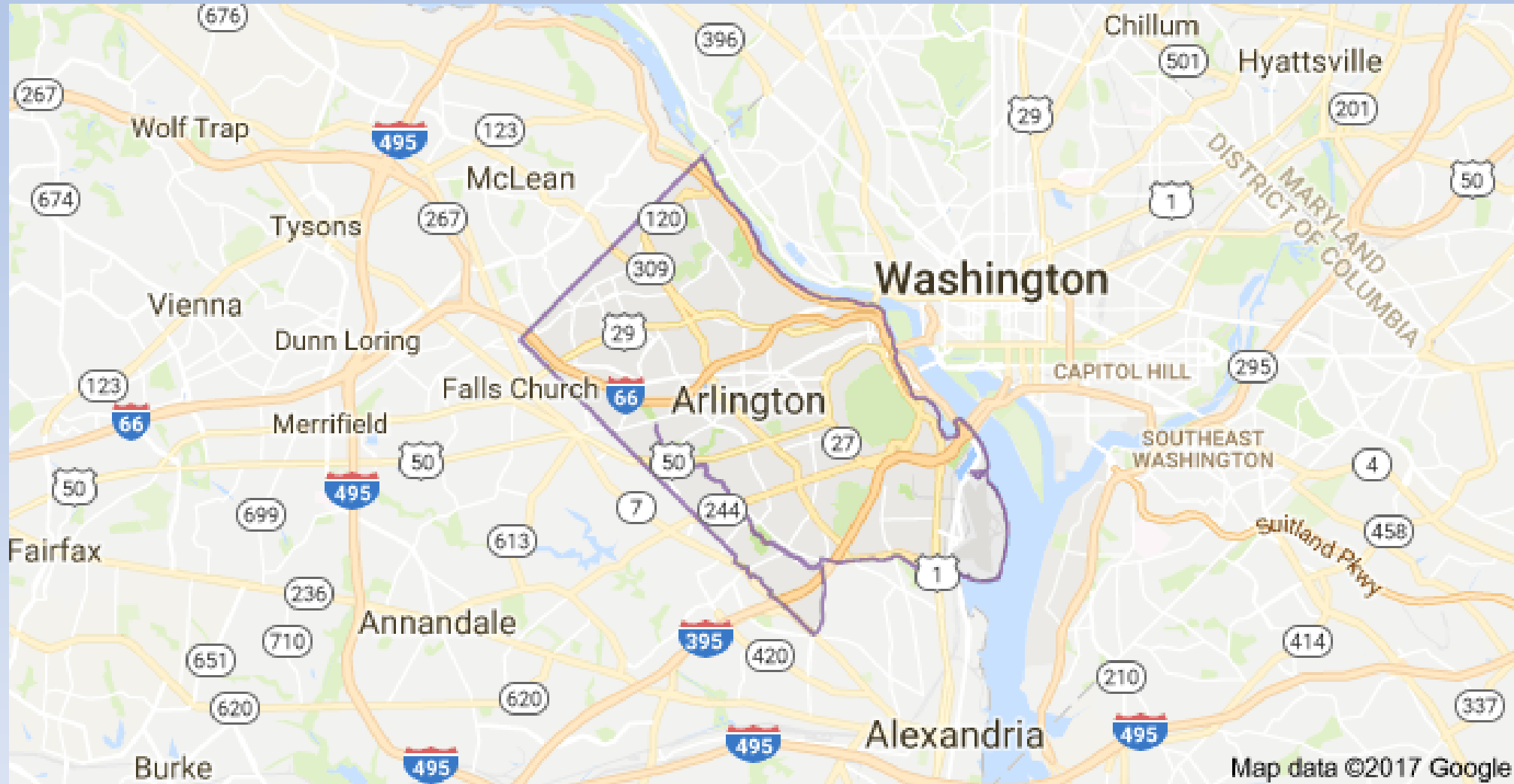
Advisor: Dr. Alexis R. Santos



# OVERVIEW



# ARLINGTON, VA AND VICINITY



# ARLINGTON HISTORY

- Arlington is an urban county of about 26 square miles located directly across the Potomac River from Washington DC.
- Originally part of the area surveyed for the nation's capital, the portion of the District on the west bank of the Potomac River was returned to the Commonwealth of Virginia by the U.S. Congress in 1846.
- This area was known as Alexandria City and Alexandria County until 1920 when the county portion was renamed Arlington County.



# HOUSING DEMAND DRIVERS

- Outstanding public school system in Arlington, ranked #1 in Virginia by Niche, and 2 of its 3 high schools received gold medals from US News.
- The American Planning Association recently recognized Arlington's commitment to community-based planning and smart growth with a [Gold 2017 National Planning Achievement Award](#).
- US News ranked the DC Metro Area as the #4 place to live in the United States for 2017. Niche ranked Arlington VA as the best city to live in in the United States for 2016 and the #3 city in 2017.



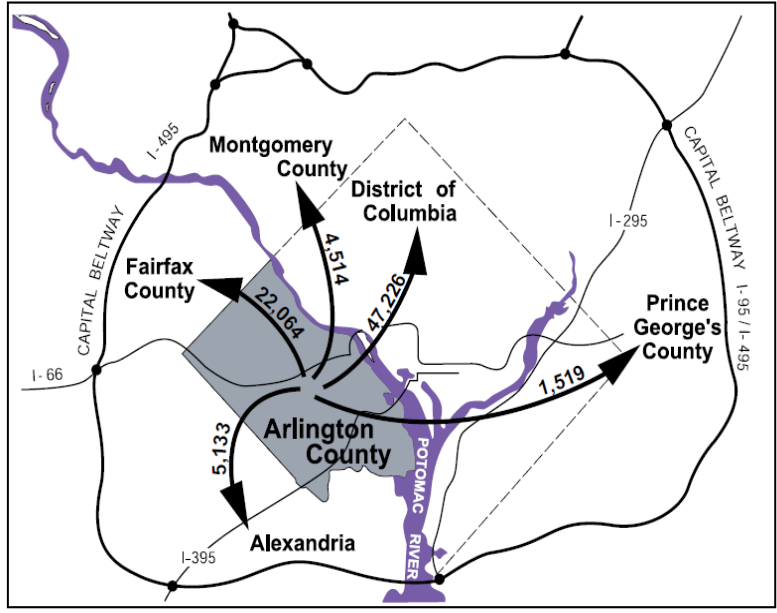
# HOUSING DEMAND DRIVERS (cont'd)

- Unemployment rate of 2.6%.
- With 40,812,259 of rentable area, Arlington has more private office space than the downtowns of Los Angeles, Denver, and Atlanta, and the CBD of Dallas and Seattle.
- Most educated county in the country. 72.9% of adults 25 and older hold a bachelor's degree or higher and 38.4% hold a graduate or professional degree.
- Arlington is in the top 10 wealthiest counties in the US based on median household income, and 2nd only to NYC in per capita income.



# POPULATION AND EMPLOYMENT

## ARLINGTON RESIDENTS WORKING IN OTHER JURISDICTIONS (2006-2010)



### TRAVEL TO OTHER LOCATIONS

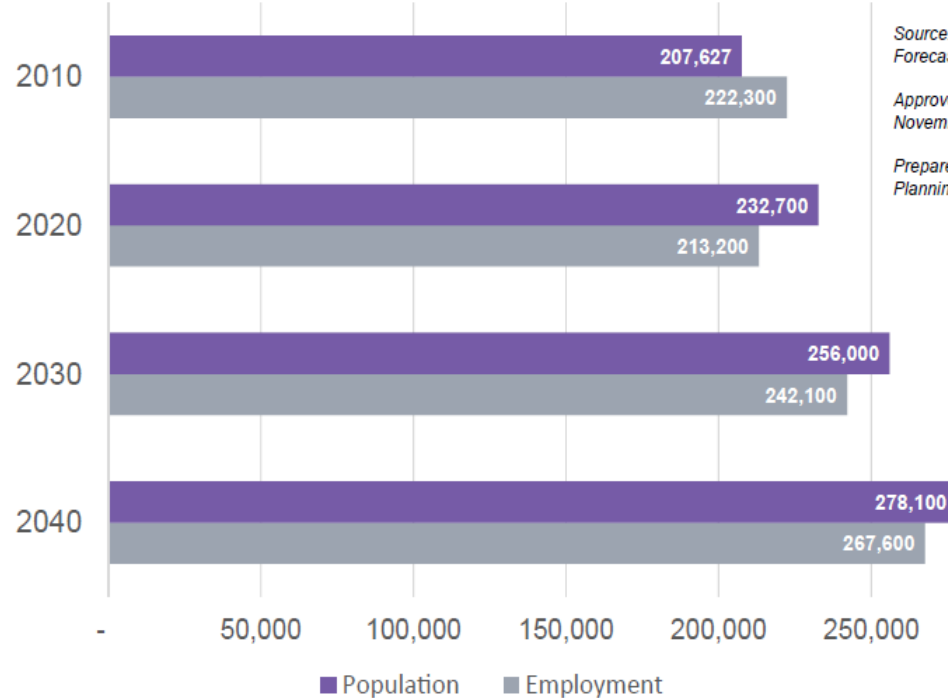
To Prince William Co., VA	843
To Loudoun Co., VA	1,251
To other places in VA	2,613
To other places in MD	951
To other states	1,198

Source: U.S. Census Bureau 2006-2010 American Community Survey.

### ARLINGTON RESIDENTS THAT LIVE AND WORK IN ARLINGTON

Arlington Resident Workers Live and Work in Arlington	40,671
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## TOTAL POPULATION AND EMPLOYMENT FORECASTS



Source: Round 9.0 Forecast  
 Approved by MWCOG November 2016.  
 Prepared by: CPHD, Planning Division.

# POPULATION DISTRIBUTION

## POPULATION

January 1, 2017 Population (Planning Division Estimate)	222,800
2010 Population (U.S. Census Bureau Decennial Census)	207,627
2000 Population (U.S. Census Bureau Decennial Census)	189,453

## AGE DISTRIBUTION

	2000		2010		January 2017	
Under 5	10,397	5.5%	11,782	5.7%	13,900	6.2%
5 - 19	24,016	12.7%	23,455	11.3%	28,100	12.6%
20 - 24	16,535	8.7%	17,704	8.5%	14,200	6.4%
25 - 34	47,675	25.2%	57,402	27.6%	58,500	26.3%
35 - 44	32,664	17.2%	32,868	15.8%	37,100	16.7%
45 - 64	40,404	21.3%	46,362	22.3%	49,900	22.4%
65 - 84	15,244	8.0%	15,239	7.3%	18,400	8.3%
85 and Over	2,518	1.3%	2,815	1.4%	2,700	1.2%
<b>Total Population</b>	<b>189,453</b>	<b>100.0%</b>	<b>207,627</b>	<b>100.0%</b>	<b>222,800</b>	<b>100.0%</b>



# EXISTING HOUSEHOLDS

## HOUSEHOLD COMPOSITION

	2000		2010		2015 ACS	
Family Households	39,322	45.5%	41,607	42.4%	45,768	46.5%
With own children under 18 years	16,625	19.3%	17,853	18.2%	21,021	21.4%
Married-couple families	12,800	14.8%	14,228	14.5%	16,433	16.7%
Male householder, no wife families	880	1.0%	867	0.9%	1,199	1.2%
Female householder, no husband families	2,945	3.4%	2,758	2.8%	3,389	3.4%
Without children under 18 years	22,697	26.3%	23,754	24.2%	24,747	25.1%
Nonfamily Households	47,030	54.5%	56,443	57.6%	52,673	53.5%
<b>Total Households</b>	<b>86,352</b>	<b>100.0%</b>	<b>98,050</b>	<b>100.0%</b>	<b>98,441</b>	<b>100.0%</b>

Source: U.S. Census Bureau - Census 2000 SF1: P18; Census 2010 SF1: P19.; ACS 2015 5-Year Estimates - B11005.

ACS = American Community Survey. Estimates represent 2011-2015. Survey administered to 6.9% of population

# SINGLE FAMILY HOUSING STOCK

- 28,500 existing single family detached homes in Arlington.
- 3,300 SFD homes in Arlington are less than 1,500 SF and 23,000 SFD homes in Arlington were built before 1960.
- Approximately 180 to 200 new SFD homes are built in Arlington each year, roughly 90% of which are a direct one to one replacement of obsolete stock.
- Approximately 325 homes undergo major renovations and additions each year.



# AFFECTS OF HOUSING STOCK CHANGES

- Individuals must compete with investors for more affordable units, often failing to compete with the easy terms offered by investors.
- The most affordable housing stock, the starter single family home, is being replaced with most expensive stock. Typically \$550,000 to \$800,000 lots and units are torn down and replaced with \$1.3MM to \$1.8MM units, or in the case of a major renovation, improved to a value \$900,000 to \$1.5MM.
- With an estimated Median Household Income for a household of 4 equal to \$151,342, homes in Arlington that are affordable to households earning the median income or below are being replaced with units only affordable to those earning 1.5 to 2.0+ times the Median Household Income for a family of 4.



# NEWS COVERAGE

The Washington Post  
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Local

## In the hunt for tear-down properties, elderly homeowners often get offers

The Washington Post  
Democracy Dies in Darkness

Local

## Arlington house tear-downs increased again in 2013, worrying preservationists

By Patricia Sullivan January 15, 2014

The Washington Post  
Democracy Dies in Darkness

Very Unfavorably

Powered By Nielsen

Real Estate

## When your home no longer meets your needs, renovating – instead of moving – may be your best bet

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MARKETS | PROPERTY REPORT

## The Land of a Thousand Teardowns

Developers knock down old houses to build big new ones in Northern Virginia's booming market



# OBJECTIVES OF THE STUDY

- Models
  - Develop a hedonic model that can be used to predict the value of a single family residential building lot based on zoning, lot size, slope, and location attributes.
  - Develop a hedonic model that can be used to predict the value of a new detached single family unit based on lot size, slope, unit attributes, and location attributes.
- Possible Applications
  - Workforce housing policy, including strategies for developing and preserving “the missing middle”.
  - Demographic forecasting
  - School planning



# DATA AND SOURCES



	Arlington County Open Data	Arlington Online Permit Data	Arlington GIS CD	Arlington Contours CD	MRIS (MLS)	National Capital Region Transportation Planning Board
Address	x	x	x		x	
Address Point			x			
Parcel	x					
Lot Square Footage	x					
Building Permit Date		x				
Lot Sale Price	x				x	
New Home Sale Price	x				x	
Sale Date						
Above Grade Finished SF					x	
Basement Area Finished SF					x	
Lower Floor Baths					x	
Main Floor Baths					x	
Upper Floor 1 Baths					x	
Upper Floor 2 Baths					x	
Lower Floor Bedrooms					x	
Main Floor Bedrooms					x	
Upper Floor 1 Bedrooms					x	
Upper Floor 2 Bedrooms					x	
Metro Station Points			x			
Zip Code Polygons			x			
Census Block Group Polygons			x			
Census Tract Polygons			x			
2' Elevation Contour Lines				x		
Major Roads			x			
Transportation Analysis Zones (TAZ)						x
TAZ Employment						x
Walk Score and Transite Score						



# COVARIATES ANTICIPATED



	Calculated	Dummy Variable	Global - Covariate	Local - Covariate
Lot Square Footage				X
Sale Date				X
Above Grade Finished SF			X	
Basement Area Finished SF			X	
Lower Floor Baths			X	
Main Floor Baths			X	
Upper Floor 1 Baths			X	
Upper Floor 2 Baths			X	
Lower Floor Bedrooms			X	
Main Floor Bedrooms			X	
Upper Floor 1 Bedrooms			X	
Upper Floor 2 Bedrooms			X	
Zip Code Polygons		X	X	
Census Block Group Polygons		X	X	
Census Tract Polygons		X	X	
Distance to a specific Metro station	X			X
Distance to WGCC	X			X
Lot elevation change	X			X
Distance to job center (driving)	X		X	
Distance to job center (walking)	X			X
Distance to elementary school	X			X
Distance to middle school	X			X
Walk Score and Transit Score			X	

# HEDONIC HOUSE PRICE MODELS

- Hedonic Regression: A regression method used to determine the value of a good or service by breaking it down into its component parts.
- Hedonic Regression methods typically employed in previous housing price research could be classified as one of two types, Ordinary Least Squares or Geographically Weighted Regression.





# HEDONIC HOUSE PRICE MODELS

- OLS - Ordinary Least Squares Regression
  - Used to identify non-spatial attribute associations of housing and land prices.
  - Typically includes non-spatial attributes related to structure, land, and neighborhood characteristics. Also includes dummy variables to represent zone inclusions such as zip code and Census geographies, and distance or time values such as commute time to CBD.
  - $P = \beta_0 + \beta_H H + \beta_N N + \beta_L L + \varepsilon$

*where  $P$  is a vector of house prices,  $H$  is a matrix of house characteristics,  $N$  is a matrix of neighborhood characteristics, and  $L$  is a matrix of location characteristics.  $\beta_0$  is the estimated constant term vector, or  $y$  intercept and  $\beta_H$ ,  $\beta_N$ , and  $\beta_L$  are vectors of the estimated coefficients.  $\varepsilon$  is a vector of the residual term.*



# HEDONIC HOUSE PRICE MODELS (continued)

- Mixed Geographically Weighted Regression (MGWR)
  - Use final OLS model as a basis for MGWR model
  - MGWR performs weighted least squares regression on subsets of the data based on a kernel function.
  - MGWR uses local and global covariates, where the global covariates have uniform coefficients throughout the study area and are therefore held constant, while local covariates are allowed to have variable coefficients throughout the study area based on local spatial effects.

$$y_i = \sum_{j=1}^k \beta_j x_{ij} + \sum_{l=k+1}^m \beta_l(u_i, v_i) x_{il} + \varepsilon_i$$



# CHALLENGES ANTICIPATED

- To obtain all necessary data to include non-MLS sales (non-listed sales).
- To develop models that are as valid in sections of the county where there is no sample data as they are in areas where there are multiple data points.
- To identify unique location based value drivers throughout the county.
- To properly identify spatial regimes that reflect the affects of unique location based value drivers while eliminating redundant features such as multiple metro stop access.
- To accurately classify and identify design and/or finish attributes that can easily affect the sales price by 5% or more.

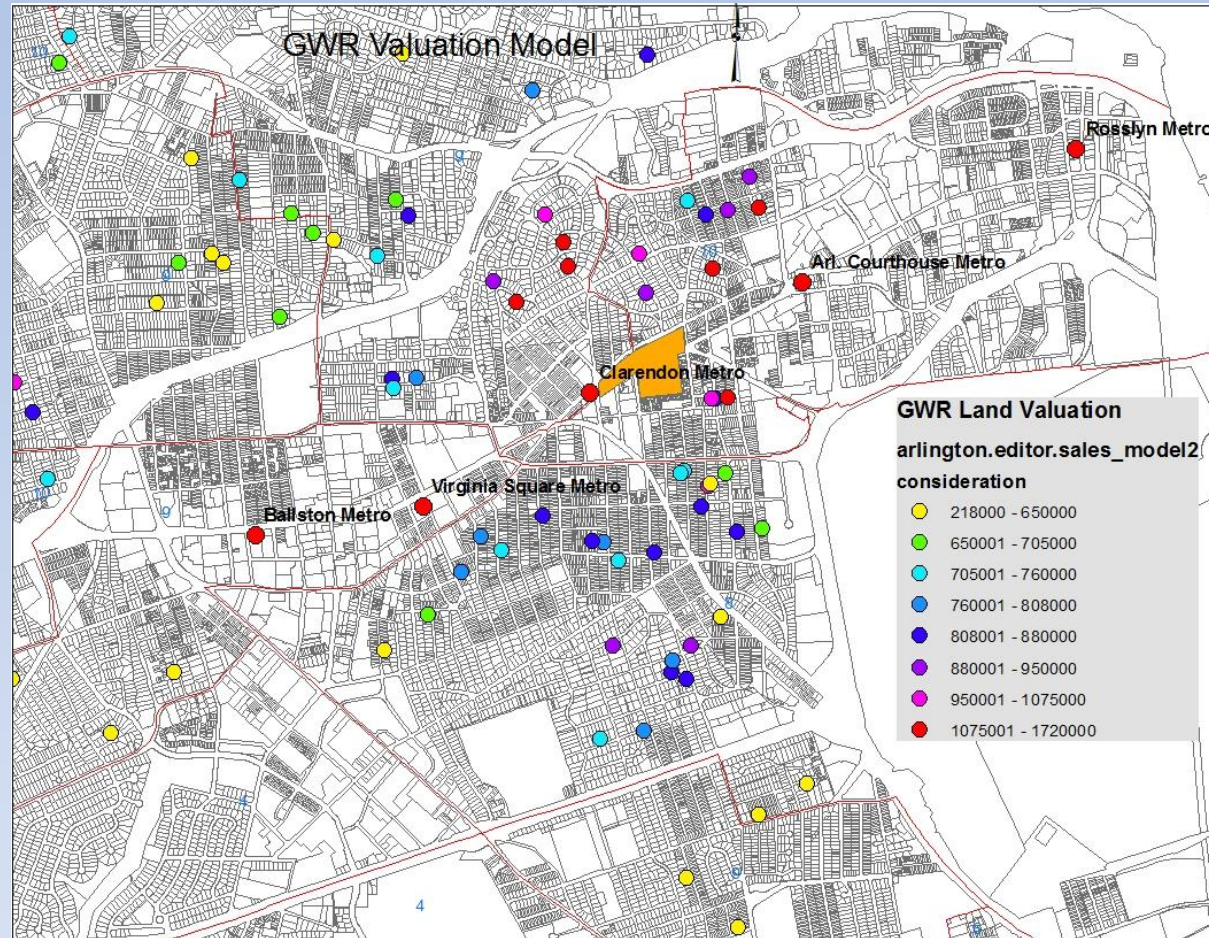


# SOFTWARE USED

- **ArcGIS:** Used for primary data storage in a file geodatabase, most data manipulation, feature creation, distance calculations, and presentation map creation. Also used for some basic exploratory regression and OLS regression.
- **QGIS and PostGIS:** Used for some data importing and more complex data queries that are not supported in ArcGIS Desktop.
- **GeoDa:** Used for spatial weights generations and regression analysis, including final OLS models and all MGWR models.

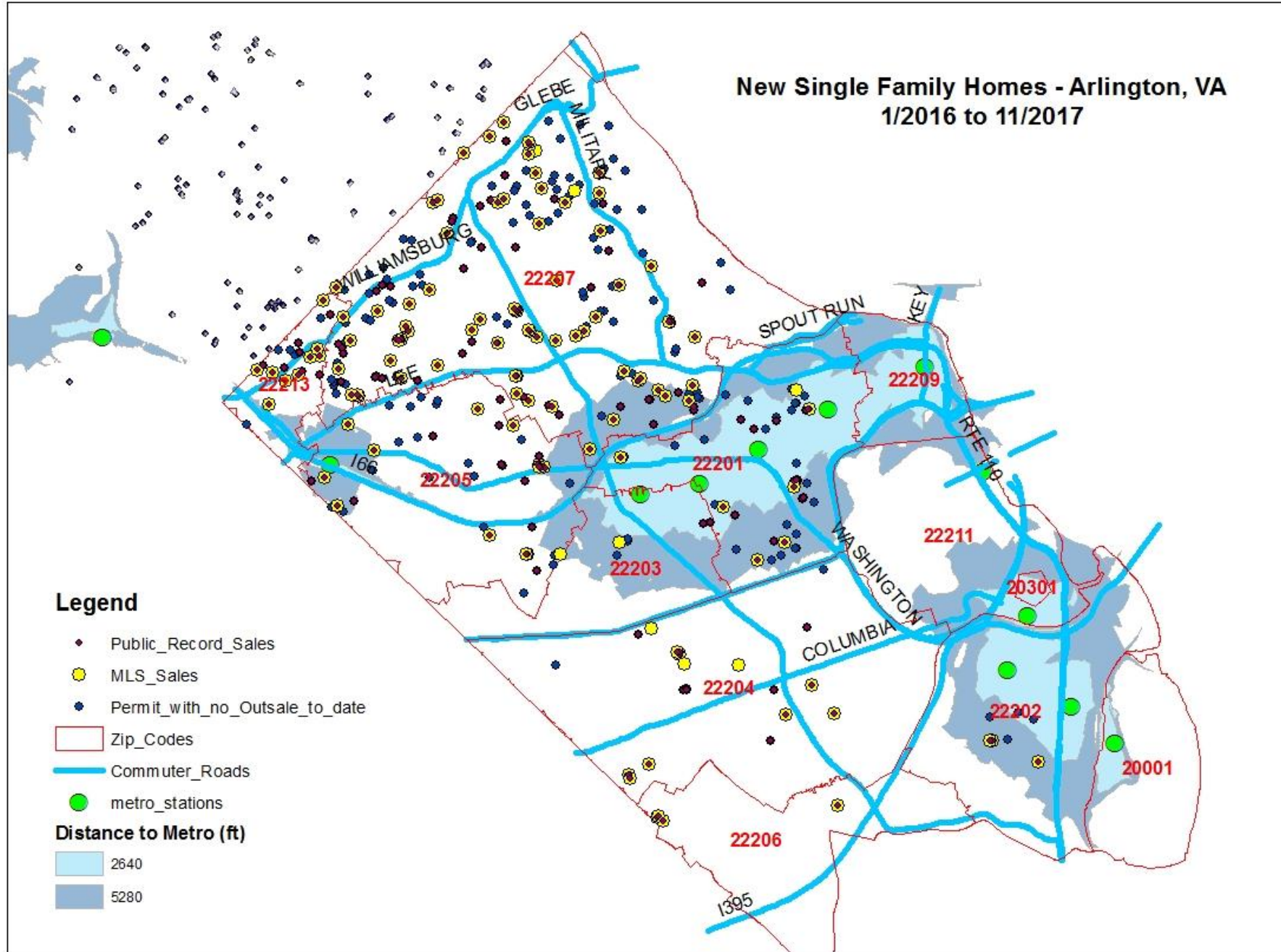


# PRELIMINARY RESULTS





# New Single Family Homes - Arlington, VA 1/2016 to 11/2017



# PRELIMINARY RESULTS

## OLS Regression via ArcGIS

$$\begin{aligned} \text{NEW HOUSE PRICE} = & 361557.28 + 41.72 * (\text{Lot Area SF}) + 155.89 * (\text{Living Area SF}) \\ & + 116679 * (\text{22207 dummy}) + 371614 * (\text{22201 dummy}) \\ & - 344537 * (\text{22204 dummy}) - 249352 * (\text{22206 dummy}) \end{aligned}$$

- Sample size of 116 data points
- Includes MLS listed properties only
- Adjusted R<sup>2</sup> value = .701
- Residuals are not normally distributed, with 6 (5.2%) of the data points over 2 standard deviations from the median, and 2 (1.7%) of the data points more than 4 standard deviations from the mean. Closer investigation of these data points is warranted to determine the accuracy of their attributes.

# FUTURE DIRECTIONS – CAPSTONE PROJECT

Tasks and Aims	1/18 – 2/18	3/18 – 4/18	5/18 – 6/18	7/18 – 9/18
Data Collection and Preparation	X			
Regression Techniques	X	X		
Model Development		X		
Final Data and Model Development			X	
Report Preparation				X



# INITIAL REFERENCES

- Marco Helbrich, Wolfgang Brunauer, Eric Vaz, and Peter Nijkamp. “Spatial Heterogeneity in Hedonic House Price Models: The Case of Austria”. *Urban Studies* Vol. 51(2) 390-411, February 2014.
- John R. Ottensmann, Seth Payton, and Joyce Man. “Urban Location and Housing Prices within a Hedonic Model”. *The Journal of Regional Analysis and Policy* Vol. 38(1):19-35, January 2008.
- Jan K. Brueckner, Jacques-Francois Thisse, Yves Zenou. “Why is central Paris rich and downtown Detroit poor?”. *European Economic Review* Vol. 43:91-107, 1999.
- Geoffrey Meen. “Spatial housing economics: A survey”. *Urban Studies* 2016, Vol. 53(10) 1987-2003

COMMENTS AND QUESTIONS  
ARE WELCOMED

Thank you for your attention!