

Development of a Household, Population, and Employment Forecast Interpolation Tool for Prince William County

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PRINCE WILLIAM

Geographic Information Systems

COG Forecast Methods



Annual Build-Out Analysis:

- Projection of maximum allowable future development. An assessment of current zoning districts, long-range land use of undeveloped lots, and potential redevelopment areas within the County. Each update is based on occupancy permits, rezonings, special use permits, and Comprehensive Plan amendments issued during current year.
- **Results:** *Quantity of residential units built* and *approximation of units yet to be built*, commonly referred to as the “pipeline”.
- **Non-residential development** is assessed using the same factors. Includes estimates of residential and nonresidential capacity in “revitalization areas” where existing development density or intensity is significantly less than permitted by existing zoning

COG Forecast Methods

Component Areas (no cities, towns or large water bodies)

Land moves through these categories as it transitions: undeveloped → zoned → developed.

- **Developed Area**

Residential and non-residential projects that have reached completion with no additional land area available for development.

- **Build-Out Area**

Undeveloped A-1 zoned land that is not in the rural area. For calculating potential development, the Comprehensive Plan's long-range land use designation was used – a high and low range for residential development and a high and average range for non-residential development.

- **Residential /Nonresidential Inventory**

Contain projects that have rezoning approval by the Board of County Supervisors and are in any development phase. Some projects may be in the middle of the construction process, some may just contain an undeveloped pad site.

- **Revitalization Areas**

Woodbridge, Triangle, and Yorkshire are older commercial corridors that are not utilized to their full potential in their current zoning district or their long-range land use designation.

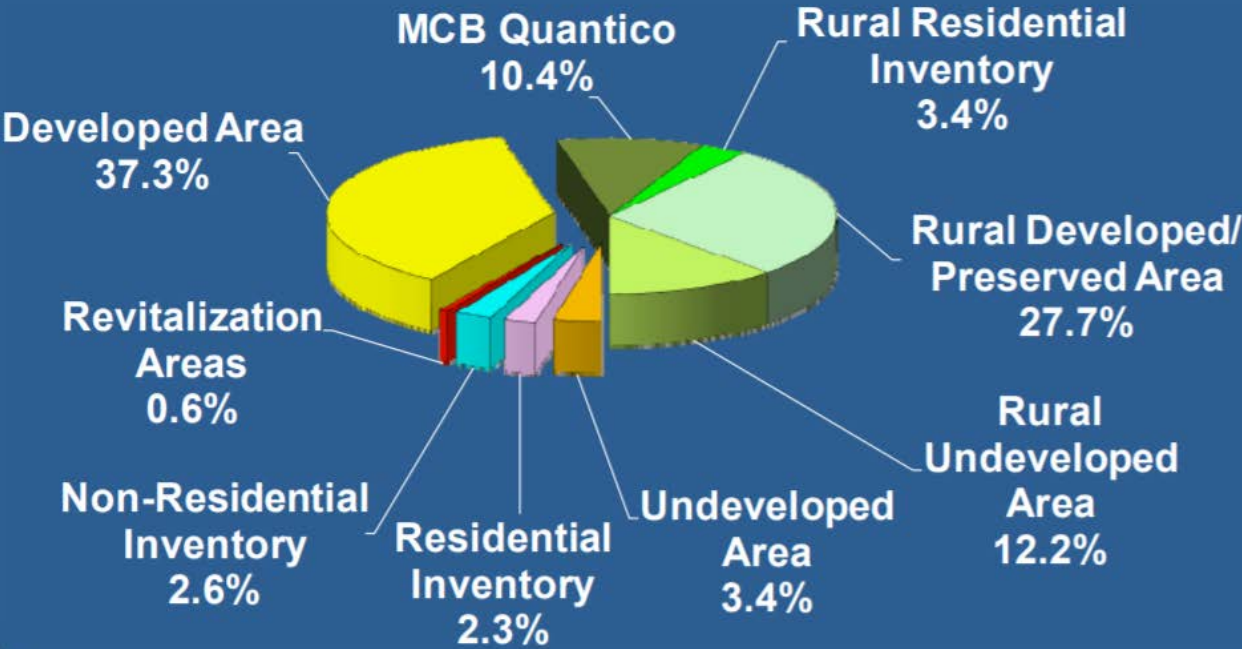
- **Rural Area**

The rural area covers more than fifty percent of the County. This area contains large residential land tracts, parks, agricultural and forested land, along with numerous small businesses.

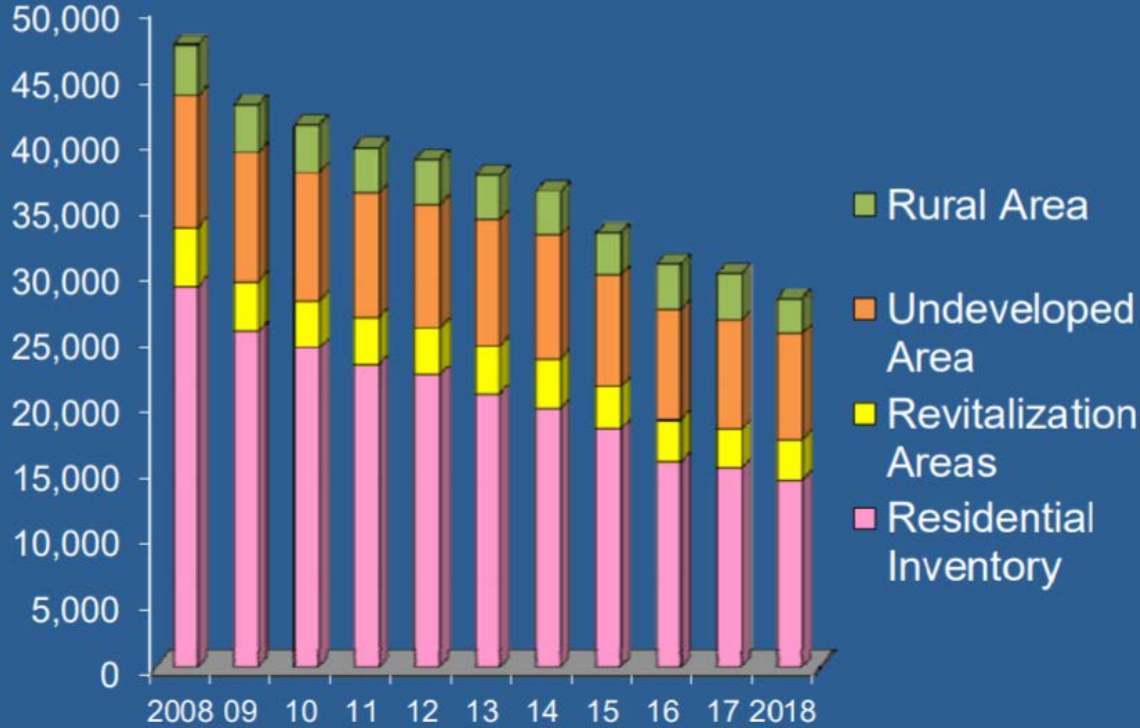
COG Forecast Methods



For purposes of the build-out analysis the County is divided into component areas.



Residential build-out capacity by component since 2008.



COG Forecast Methods



Forecast Calculation

- **Households**

- **Logistic curve projection** for households by year, based on upper limit method (*upper bound or limiting value*). 26 observations: 1995-2020.
- Growth accelerates quickly and gradually decreases until upper limit is reached.
- Agreed upon value for upper limit-COG 9.1 (higher than build-out): 215,000 households.

- **Population**

- **Population calculated based on household forecasts.**
- **Actual average household sizes applied to 2010 and 2015 households**, and estimated average household size (scaled back by factor) applied to 2020-2045 households.

- **Employment**

- **Logistic curve projection** for employment by year (up until COG 9.0 forecasts, we used a linear curve) based on upper limit method. 26 observations: 1995-2020.
- Agreed upon value for upper limit-COG 9.1: 290,000 jobs.

COG Forecast Interpolation Tool



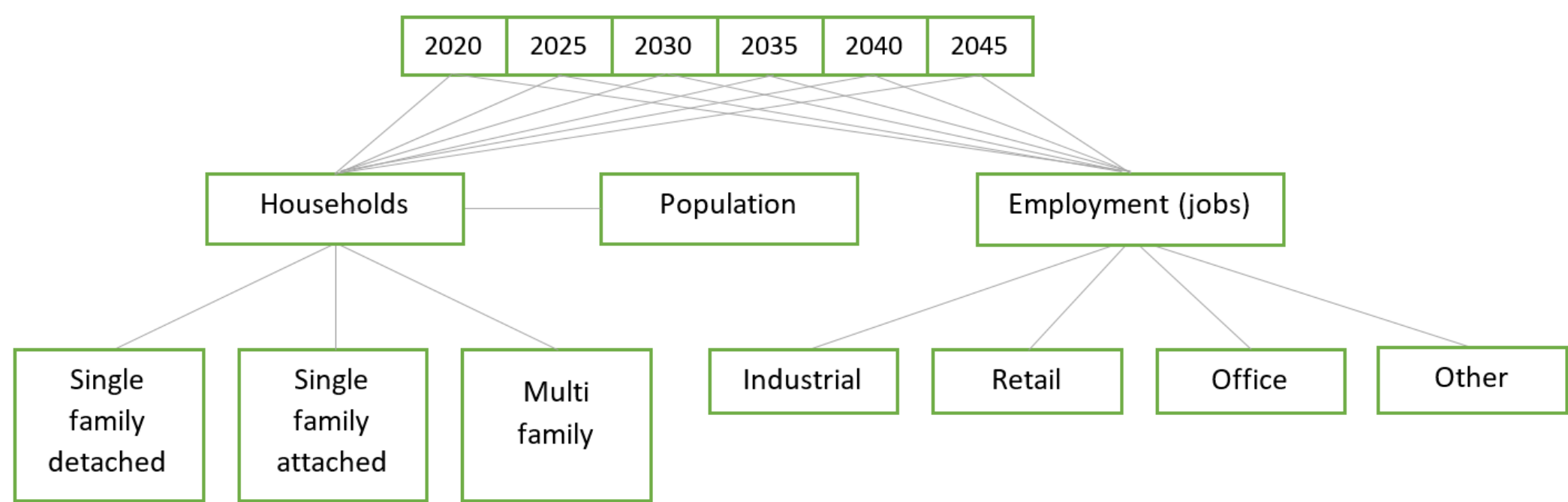
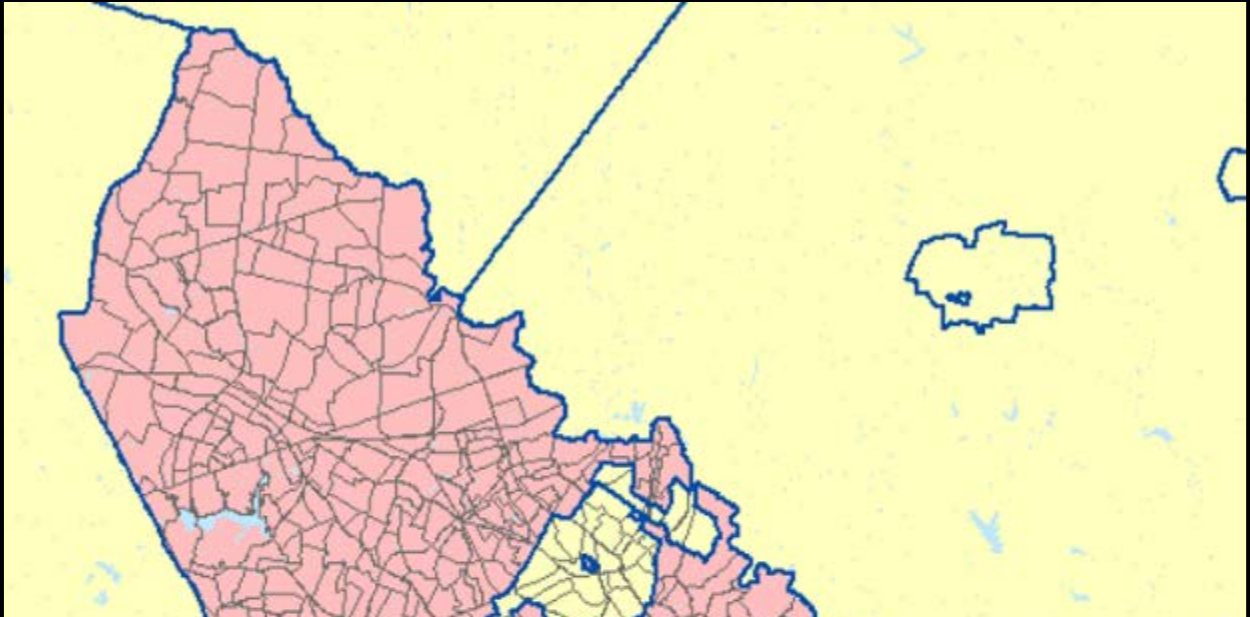
Objectives

1. Classify Prince William County zoning codes as residential or employment and further categorize residential zoning codes by type of housing unit and employment zones by employment sector.
2. Design a COG forecast interpolation tool that generates household, population, and employment forecasts for any UIF by interpolating forecast data stored in TAZs and produces results in the form of an Excel spreadsheet.
3. Develop and include verification and accuracy outputs with the interpolation results.
4. Provide an easy-to-use interface for the geoprocessing tool on an accessible web application.

Data

Transportation Analysis Zones

- 730 TAZs
- 6 forecast years
 - 3 primary variables
 - 7 secondary variables








































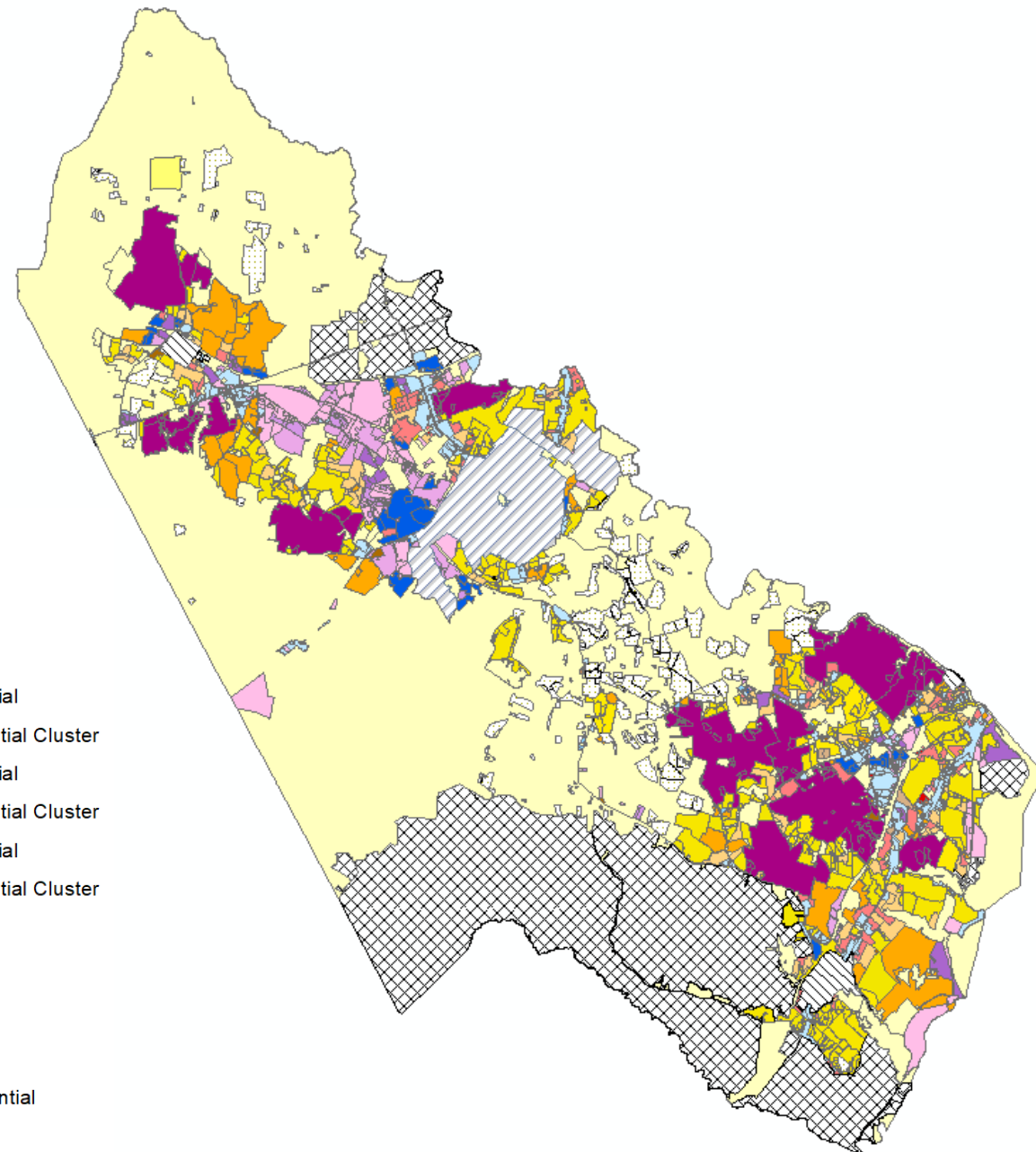
Data

Zoning Areas: Used to Guide Interpolation to Input Feature

- ~40 zoning classes

Zoning Classes

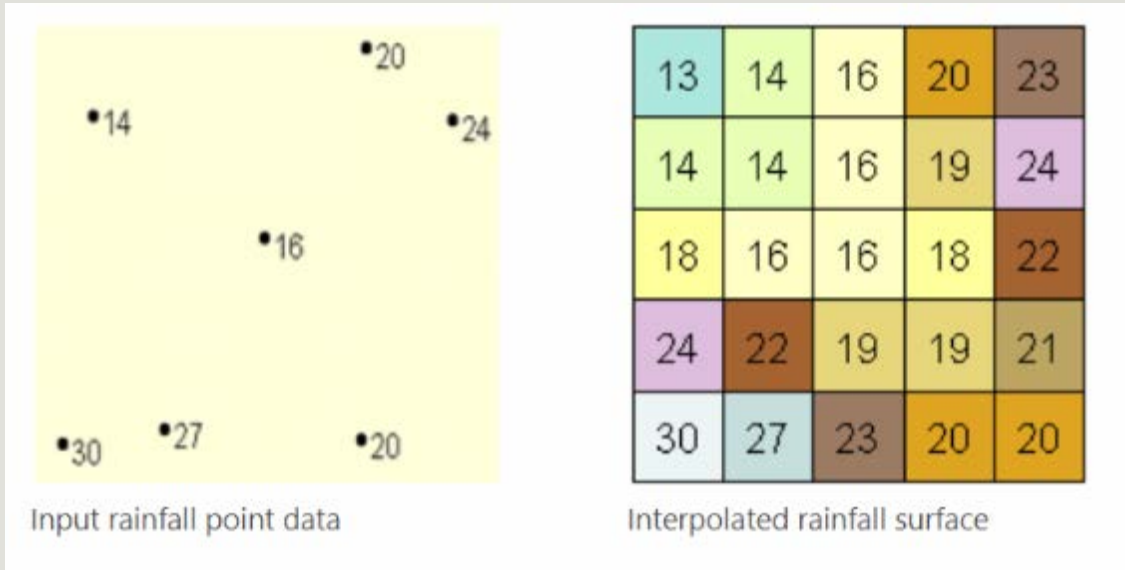
	A-1 Agricultural		PBD Planned Business District Mixed Nonresidential		SR-1 Semi-rural Residential
	A-1C Agricultural Cluster		PMD Planned Mixed District Mixed Residential and Non-Residential		SR-1C Suburban Residential Cluster
	B-1 General Business		PMR Planned Mixed Residential		SR-3 Semi-rural Residential
	B-2 Neighborhood Business		R-16 Suburban Residential		SR-3C Suburban Residential Cluster
	B-3 Convenience Business		R-2 Suburban Residential		SR-5 Semi-rural Residential
	B-R Regional Business		R-2C Suburban Residential Cluster		SR-5C Suburban Residential Cluster
	CTY City		R-30 Urban Residential		TWN Town
	FED Federal		R-4 Suburban Residential		V Village
	M-1 Heavy Industrial		R-4C Suburban Residential Cluster		
	M-2 Light Industrial		R-6 Suburban Residential		
	M/T Industrial/Transportation		R-U Urban Residential		
	O(F) Office Flex Research and Development		RC Recreation and Entertainment		
	O(H) High-Rise Office		RMH Suburban Residential- Residential Mobile Home		
	O(L) Low-Rise Office		RPC Residential Planned Community Mixed Residential and Non-Residential		
	O(M) Mid-Rise Office				



Methods

Interpolation

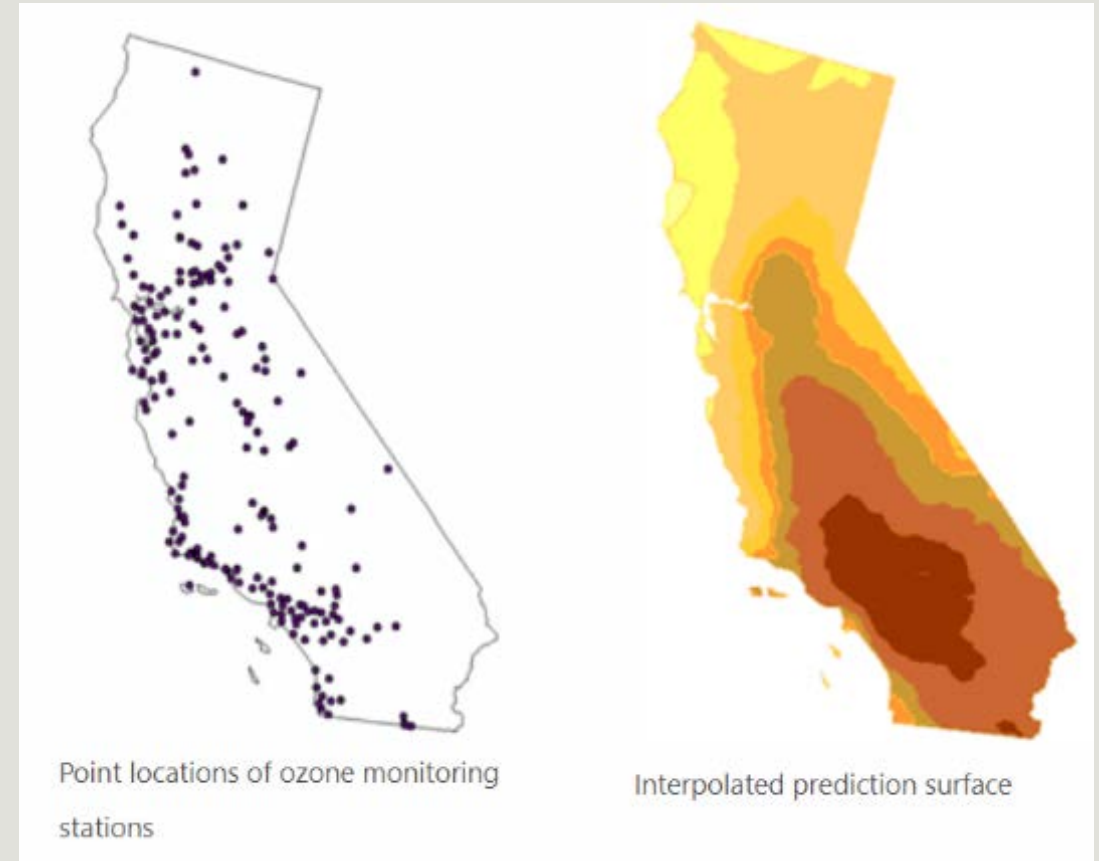
Literal: Insert something of a different nature into something else



Raster interpolated from point values

Predicted using values of nearby points

Source: ESRI



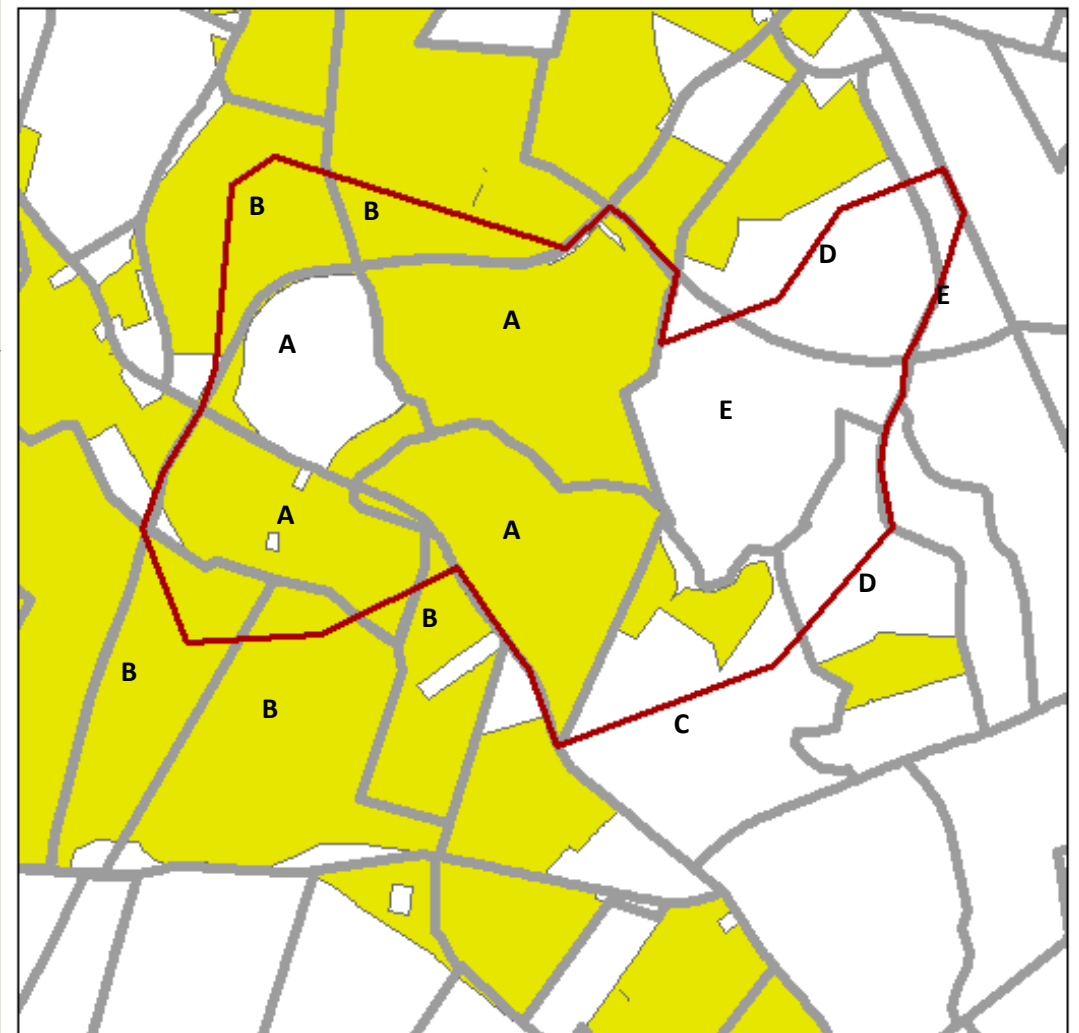
Interpolation using kriging

Methods

Weighted Areal Interpolation

Reaggregation of data from one set of polygons (SOURCE ZONES) to another set of polygons (TARGET ZONES) using ancillary data

- A.** 100% of the TAZ is in the user input feature (UIF) and the UIF receives **100%** of the population data housed within the TAZ because all residential zoning is within the UIF.
- B.** The UIF receives only a portion of the population data in these TAZs.
- C.** Even though the UIF cuts through the TAZ, 100% of residential zones in the TAZ fall within the UIF. The UIF receives 100% of the population data.
- D.** The UIF boundaries slices through the TAZ and 100% of residential zones lie outside the UIF. Therefore, the UIF receives no population data from this TAZ.
- E.** The TAZ contains no residential zones. Whether the TAZ is fully or partially within the UIF, the UIF will receive no population data because there is 0 population in this TAZ.






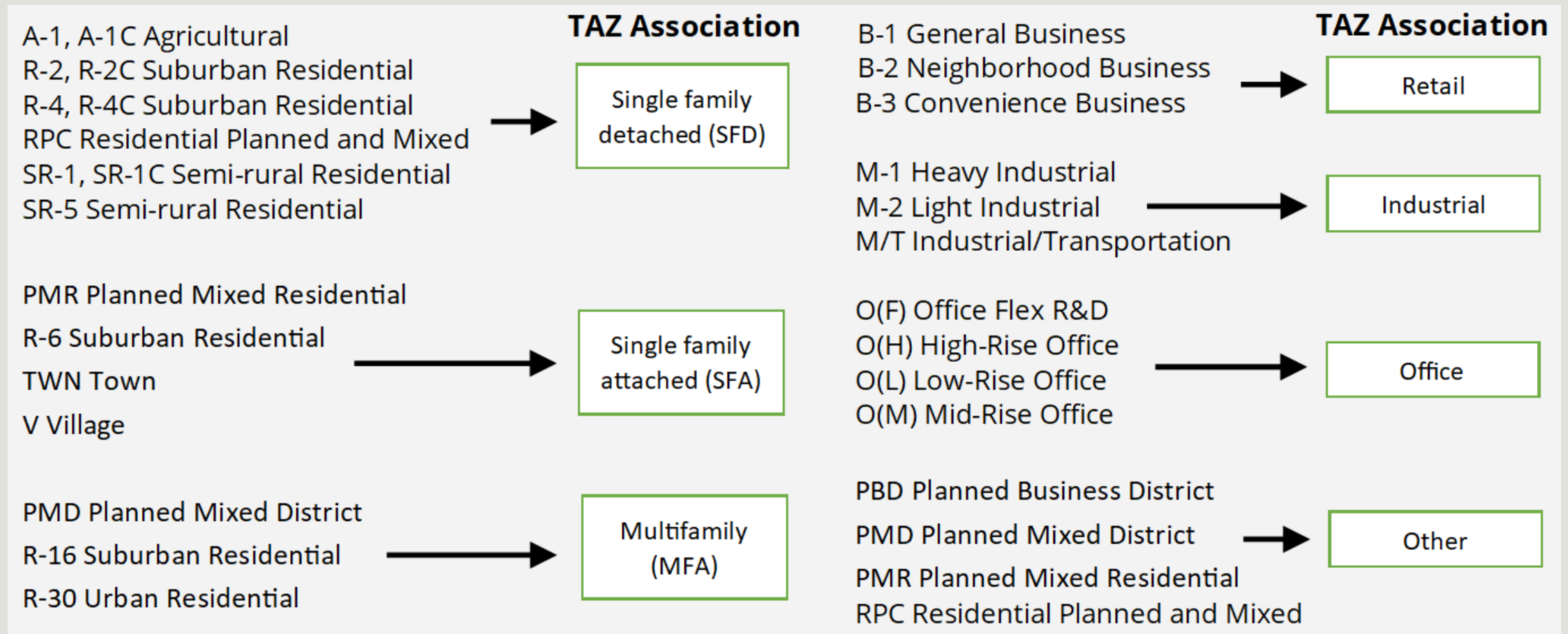
-  User Input Feature
-  TAZ Boundaries
-  Residential Zones

Figure 3

Methods

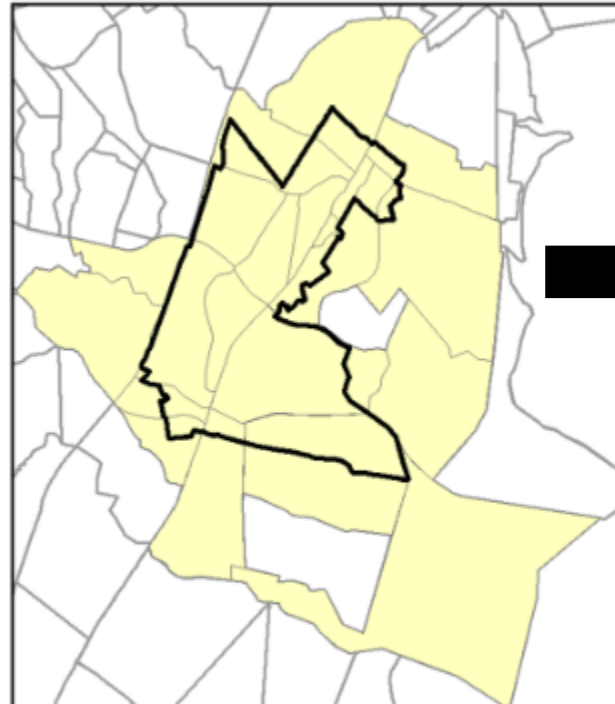
PWC Zoning → COG Forecast associations



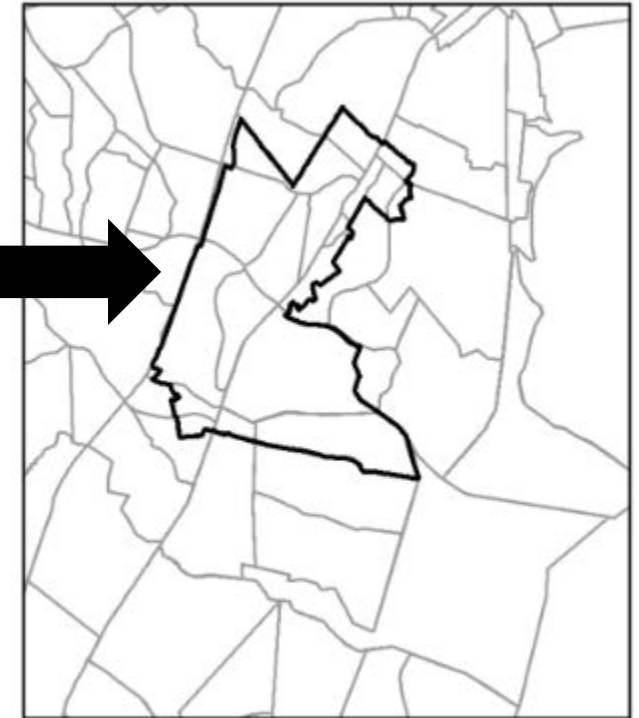
Methods

Areal Interpolation of Forecast Data

TAZs that intersect UIF



User input feature (UIF) and TAZs



PWCTAZ	IND2015	IND2020	IND2025	IND2030	IND2035	IND2040	IND2045	RET2015	RET2020	RET2025	RET2030	RET2035	RET2040	RET2045	OFF2015	OFF2020	OFF2025	OFF2030
2784A	0	0	0	0	0	0	0	46	48	49	50	51	52	53	55	55	55	55
2757B	1	1	1	1	1	1	1	439	453	461	469	477	483	493	240	241	241	241
2756A	0	0	0	0	0	0	0	15	55	78	100	121	129	141	480	502	512	521
2755A	81	81	81	81	81	81	81	0	0	0	0	0	0	0	506	506	506	506
2768C	248	257	262	267	272	275	278	132	135	137	139	140	141	142	48	55	58	61
2773A	0	0	0	0	0	0	0	441	441	441	441	441	441	441	149	149	149	149
2774A	2	2	2	2	2	2	2	78	78	78	78	78	78	78	58	63	65	67
2753A	0	0	0	0	0	0	0	1,629	1,720	1,771	1,822	1,871	1,889	1,915	150	249	293	336
2773C	12	12	12	12	12	12	12	412	418	421	424	427	428	430	306	306	306	306
2772A	929	929	929	929	929	929	929	4	6	7	8	9	10	11	90	90	90	90
2775A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	21	21	21
2773B	0	0	0	0	0	0	0	18	23	26	29	32	33	34	51	51	51	51
2732B	0	0	0	0	0	0	0	207	266	299	332	363	374	391	0	3	4	5
2776A	12	12	12	12	12	12	12	47	97	125	152	179	189	203	65	118	141	164
2732C	0	0	0	0	0	0	0	0	81	126	171	214	230	253	21	25	27	29
2776B	0	0	0	0	0	0	0	6	7	7	7	7	7	7	41	41	41	41
2777A	0	0	0	0	0	0	0	97	97	97	97	97	98	100	254	254	254	254
2779A	0	0	0	0	0	0	0	0	6	9	12	15	16	18	17	27	31	35
2785B	0	0	0	0	0	0	0	8	8	8	8	8	8	8	732	732	732	732
2785A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	30	30	30
2778A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	52	52	52
2778B	11	11	11	11	11	11	11	13	13	13	13	13	13	13	9	9	9	9

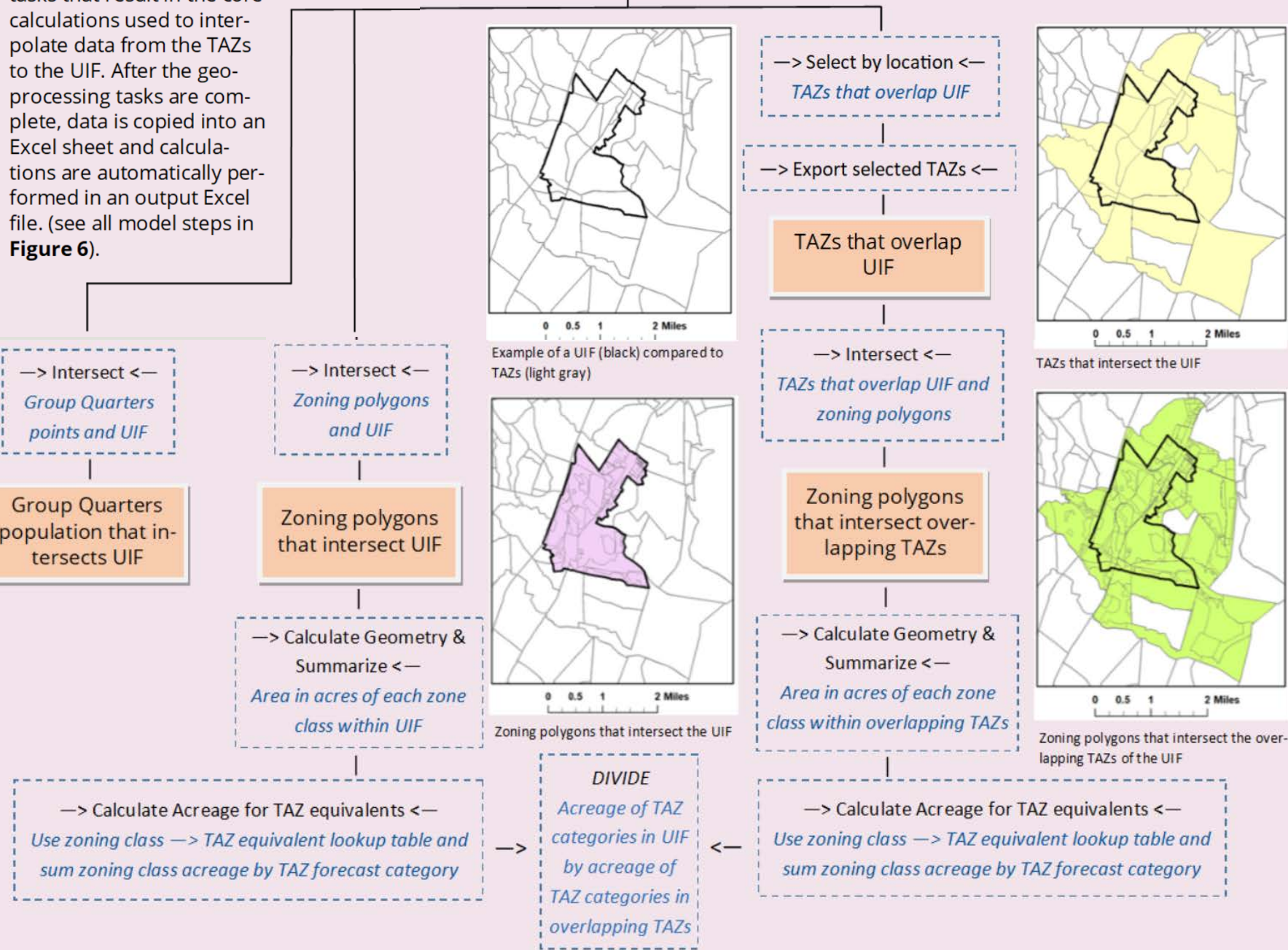
Interpolation Model

Includes geoprocessing tasks that result in the core calculations used to interpolate data from the TAZs to the UIF. After the geoprocessing tasks are complete, data is copied into an Excel sheet and calculations are automatically performed in an output Excel file. (see all model steps in **Figure 6**).

UIF

"UIF" = user input feature

"TAZ" = transportation analysis

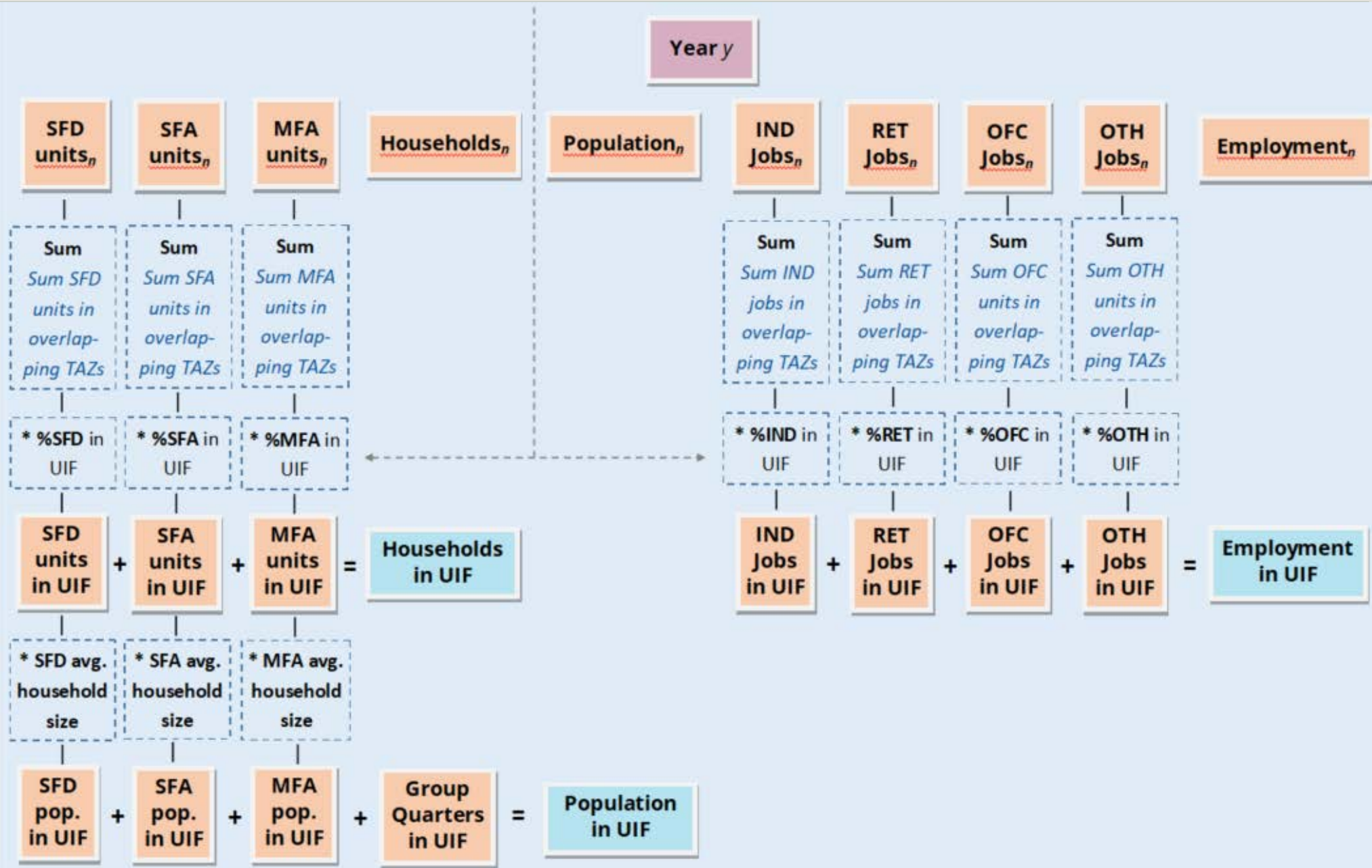


Methods

Summary of Zones by Area

CLASS	TAZ Association	Area (Acres)
A-1	SFD	329.3
B-1	RETAIL	495.0
M-2	INDUSTRIAL	10.8
O(H)	Office	97.3
O(L)	Office	19.2
PMD	MFA, Other	33.8
PMR	SFA, Other	82.4
R-16	MFA	221.0
R-30	MFA	27.3
R-4	SFD	132.2
R-6	SFA	38.4
RPC	SFD, OTHER	335.3

TOTALS	
Residential	
SFD	796.8
SFA	120.8
MFA	282.1
Employment	
INDUSTRIAL	10.8
RETAIL	495.0
OFFICE	116.5
OTHER	451.5



Calculations and Building User Output

Python

- **Select by Location, Copy Features, Intersections, Summary**
 - `arcpy.SelectLayerByLocation_management`
 - `arcpy.CopyFeatures_management`
 - `arcpy.Intersect_analysis`
 - `arcpy.AddGeometryAttributes_management`
 - `arcpy.Statistics_analysis`
- **Excel Output**
 - **Summary Zones to TAZ forecast categories:** `arcpy.da.SearchCursor`, `association.append`, `.has_key` in “if” statements.
 - `openpyxl` module: generate Excel spreadsheets (compatibility), add sheets, write to cells, etc.
Paste summary tables into Excel sheets
 - **Transfer forecast data stored in overlapping TAZs in a new Excel sheet.** *write*
 - **Perform calculations based on acreage percentages, add to results sheet**

Output

Interpolation Results for User Input Feature										Percentages of Total						
	2015	2020	2025	2030	2035	2040	2045	ZUZU-2040 Chang	ZUZU-2040 %	2015	2020	2025	2030	2035	2040	2045
Households	10,442	11,230	12,795	14,090	15,088	15,979	16,772	4,749	42.3%							
Single Family Detached	6,812	7,291	7,850	8,326	8,734	9,091	9,403	1,800	24.7%	65.2%	64.9%	61.4%	59.1%	57.9%	56.9%	56.1%
Single Family Attached	2,984	3,041	3,468	3,692	4,267	4,690	5,066	1,639	53.9%	26.6%	27.1%	27.1%	27.6%	28.4%	29.3%	30.2%
Multi-family	646	898	1,477	1,672	2,067	2,208	2,303	1,310	145.8%	6.2%	8.0%	11.5%	13.3%	13.7%	13.8%	13.7%
Population (with GQ)	33,185	35,523	39,973	43,717	46,696	49,378	51,781	13,855	39.0%							
Group Quarters (GQ) Population	97	97	97	97	97	97	97	0	0.0%							
Employment (Jobs)	11,550	15,955	20,063	24,115	28,024	32,034	35,354	16,079	100.8%							
Industrial	7,731	9,477	11,030	12,563	14,043	15,411	16,616	5,934	62.6%	66.9%	59.4%	55.0%	52.1%	50.1%	48.1%	47.0%
Retail	1,126	1,830	2,499	3,159	3,798	4,169	4,733	2,339	127.8%	9.7%	11.5%	12.5%	13.1%	13.6%	13.0%	13.4%
Office	1,084	2,128	3,142	4,142	5,107	5,989	6,768	3,862	181.5%	9.4%	13.3%	15.7%	17.2%	18.2%	18.7%	19.1%
Other	1,610	2,520	3,391	4,251	5,076	6,464	7,237	3,944	156.5%	13.9%	15.8%	16.9%	17.6%	18.1%	20.2%	20.5%

Verification Check: Difference from original forecast totals in overlapping TAZs.

Households	0	0	0	0	0	0	0
Population	-678	325	-90	-139	-145	-125	-145
Employment	0	0	0	0	0	0	0

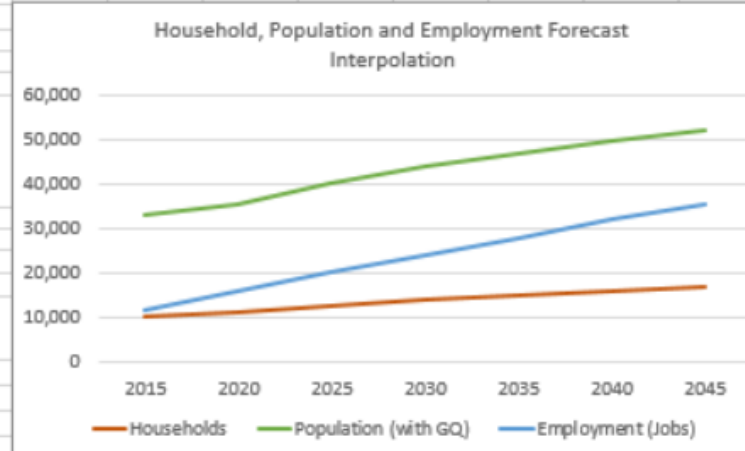
Interpolation Accuracy: Difference between interpolation results using household type, size, and employment sector (above) versus a basic calculation based on total land area of residential or employment (below: how many more or less households, population, or jobs in interpolation calculations in the table above versus a more simplified calculation).

Households	-667	-1,033	-1,853	-2,400	-2,654	-2,829	-2,936
Population	-1,759	-1,807	-3,956	-5,205	-5,760	-6,117	-6,349
Employment	-1,819	-3,035	-4,200	-5,349	-6,460	-7,275	-8,191

Summary of Zoning Association Acreage in Input Feature

	Acres	% of Total	Sector
Total Acres in Input Feature	17,796.2		
Residential	13,978.8	78.5%	
SFD	12,464.0	70.0%	89.2%
SFA	1,377.1	7.7%	9.9%
MFA	137.7	0.8%	1.0%
Employment	5,413.77	30.4%	
INDUSTRIAL	2,696.2	15.2%	49.8%
RETAIL	130.9	0.7%	2.4%
OFFICE	28.5	0.2%	0.5%
OTHER	2,558.2	14.4%	47.3%

*Residential and Employment acreage do not add up to total acres in the input feature because zoning polygons such as PMD, PMR, and RPC are mixed and



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