Population And Demand Allocation Using Polygon Overlay Techniques

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TYPICAL HIGHLY URBANIZED MEDIUM SIZED CITY

Introduction

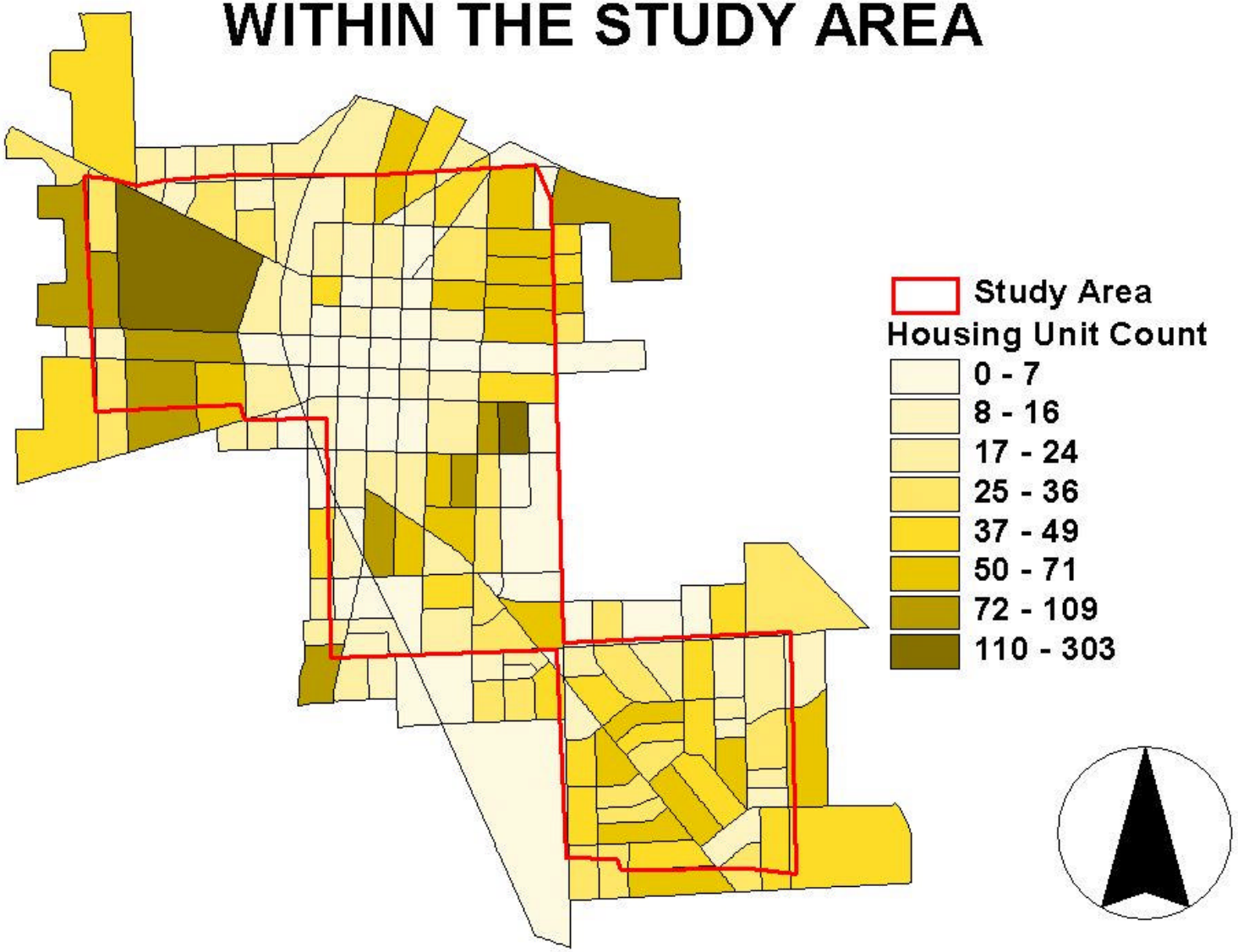
- The engineering analysis of water distribution and wastewater collection networks involves estimating the flow rates at specified points in the system.
- The flow rate needed is a function of the population served and/or the type of activities served.
- The activities are classified by land use.

Demographics: Population Distribution

Population and Housing Statistics are organized in Demographics coverages.

The Statistics are “Aggregated” by Geographic Location (Demographics Polygons).

HOUSING UNIT COUNTS WITHIN THE STUDY AREA



WATER DEMAND IS RELATED TO LAND USE

- Commercial

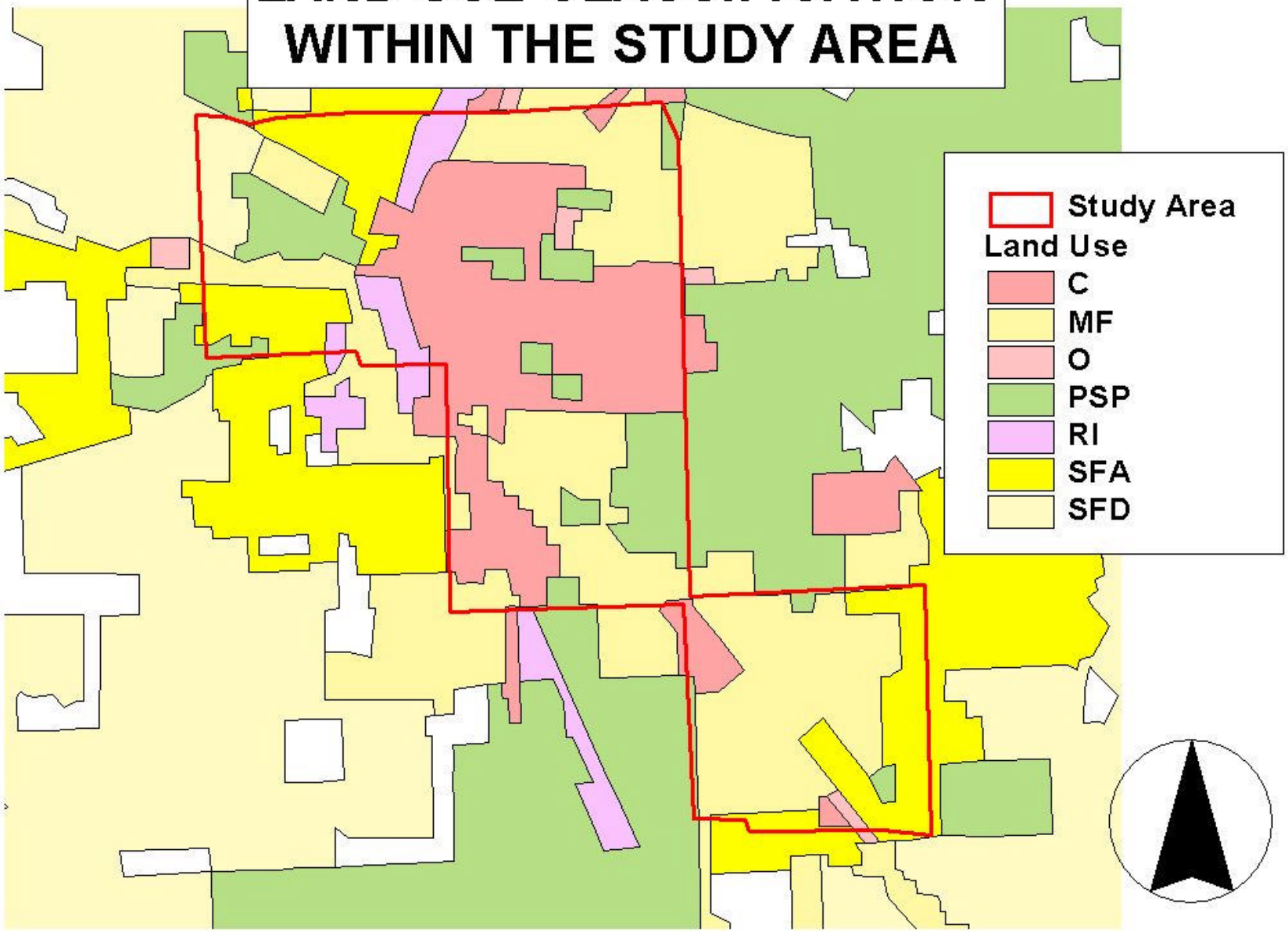
  Spans wide range, effected by season.
- Industrial

  A function of production.
- Recreational

  Wide seasonal fluctuation
- Residential

  Function of demographics

LAND USE CLASSIFICATION WITHIN THE STUDY AREA



Detailed Land Use Classification Required

- Commercial Water Use
  - Restaurants,
  - Laundries,
  - Car Washes,
  - Offices,
  - Services,
  - Retailers,…

Detailed Land Use Classification Required

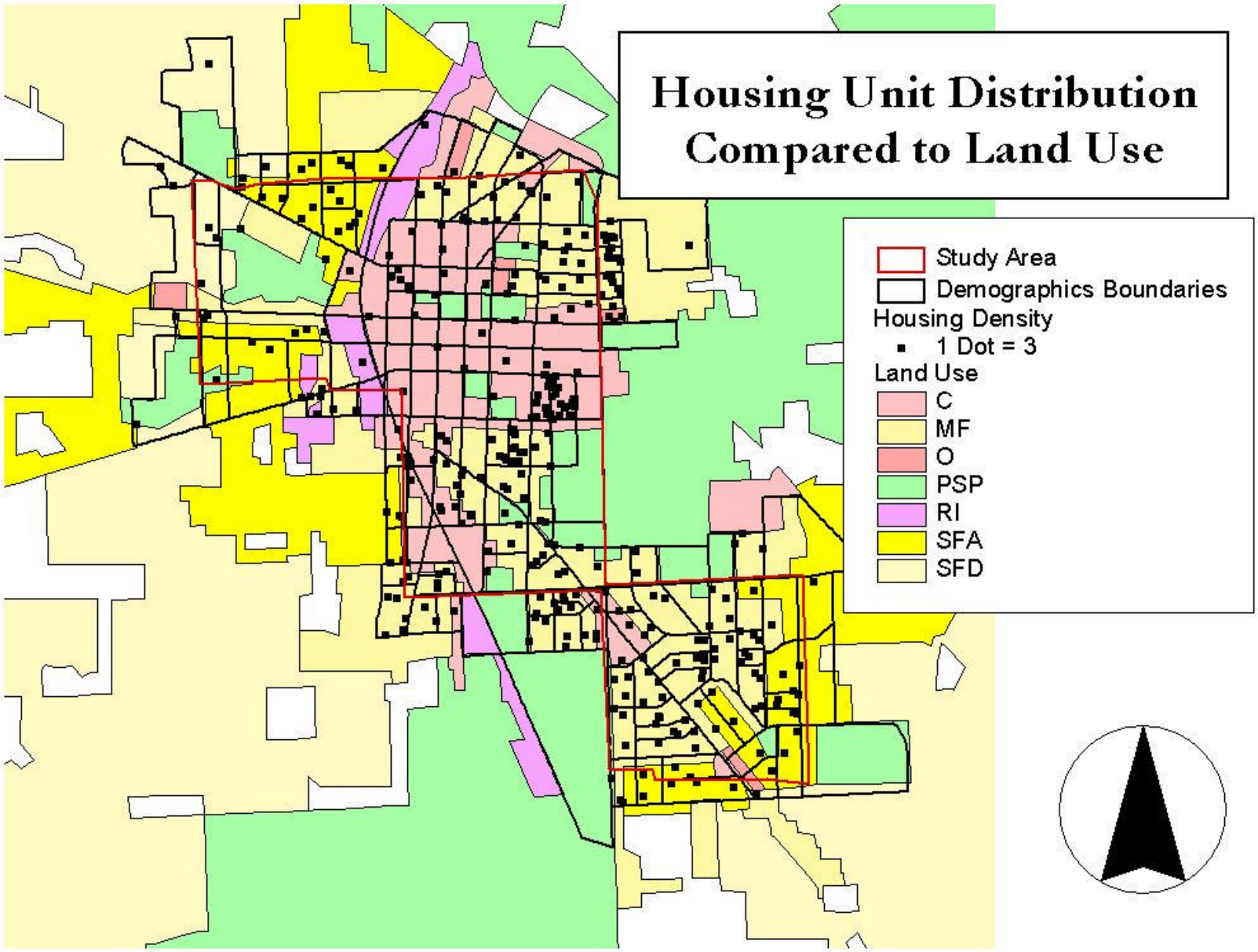
- Industrial Water Use:
  - Chemical Processing,
  - Food Processing,
  - Publishing,
  - Foundries,
  - Assembly Plants,
  - Smelters,…

Detailed Land Use Classification Required

- Recreational:
  - Water Parks,
  - Amusement Parks,
  - Golf Courses,
  - Sports Fields,
  - Nature Preserves and Conservation Areas,
  - Community Green Space,...

Detailed Land Use Classification Required

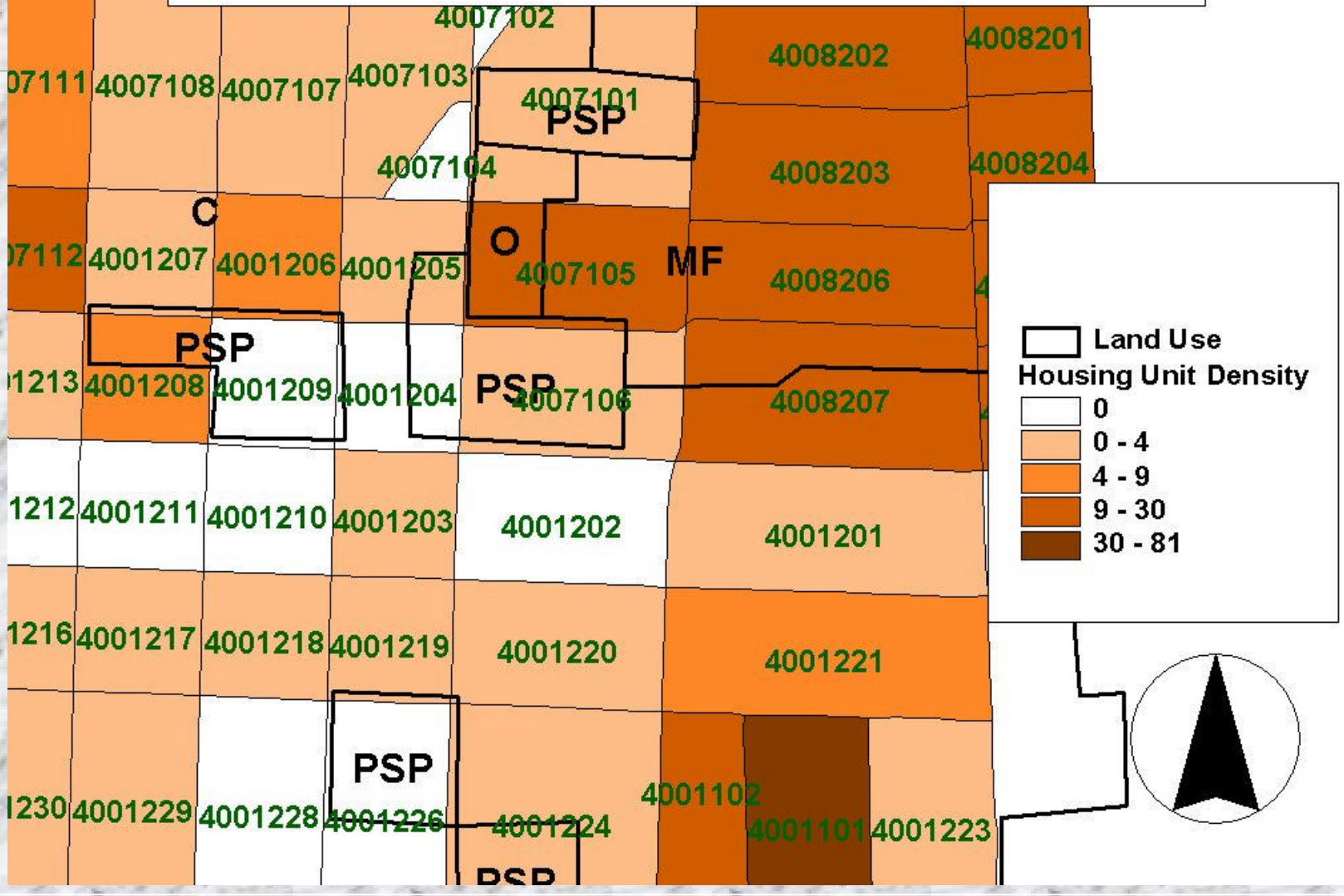
- Residential:
  - Single Family Dwellings,
  - Duplexes,
  - Condominiums,
  - Apartments,
  - High Rise Apartments,...


Housing Unit Distribution
Compared to Land Use
Study Area
Demographics Boundaries
Housing Density
1 Dot = 3
Land Use
C
MF
O
PSP
RI
SFA
SFD

Task Definition

- Land use maps are prepared based on classification schemes pertinent to demand estimation.
- Demographics maps and land use maps are overlaid, combining the attributes of both.
- The task is to aggregate the demographic statistics within areas of land use within service areas of water distribution or wastewater collection.

LAND USE CLASSES ON HOUSING UNIT DISTRIBUTION PRIOR TO PROCESSING



Overview

- “Demand” is an estimate of the water flow at specific points in a distribution or collection network.
- Residential demand is estimated using land use and population.
- “Allocation” is the process of determining where to apply demand
- “Aggregation” is the summation of statistics on the basis of geographic location.

The Polygon Overlay Technique

The polygon overlay technique is the process that links the land use and demographics prior to demand calculation. At the end of the process, the population or housing units (our example uses housing units) will be re-aggregated for a total for each service area.

The process is completed in 6 steps:

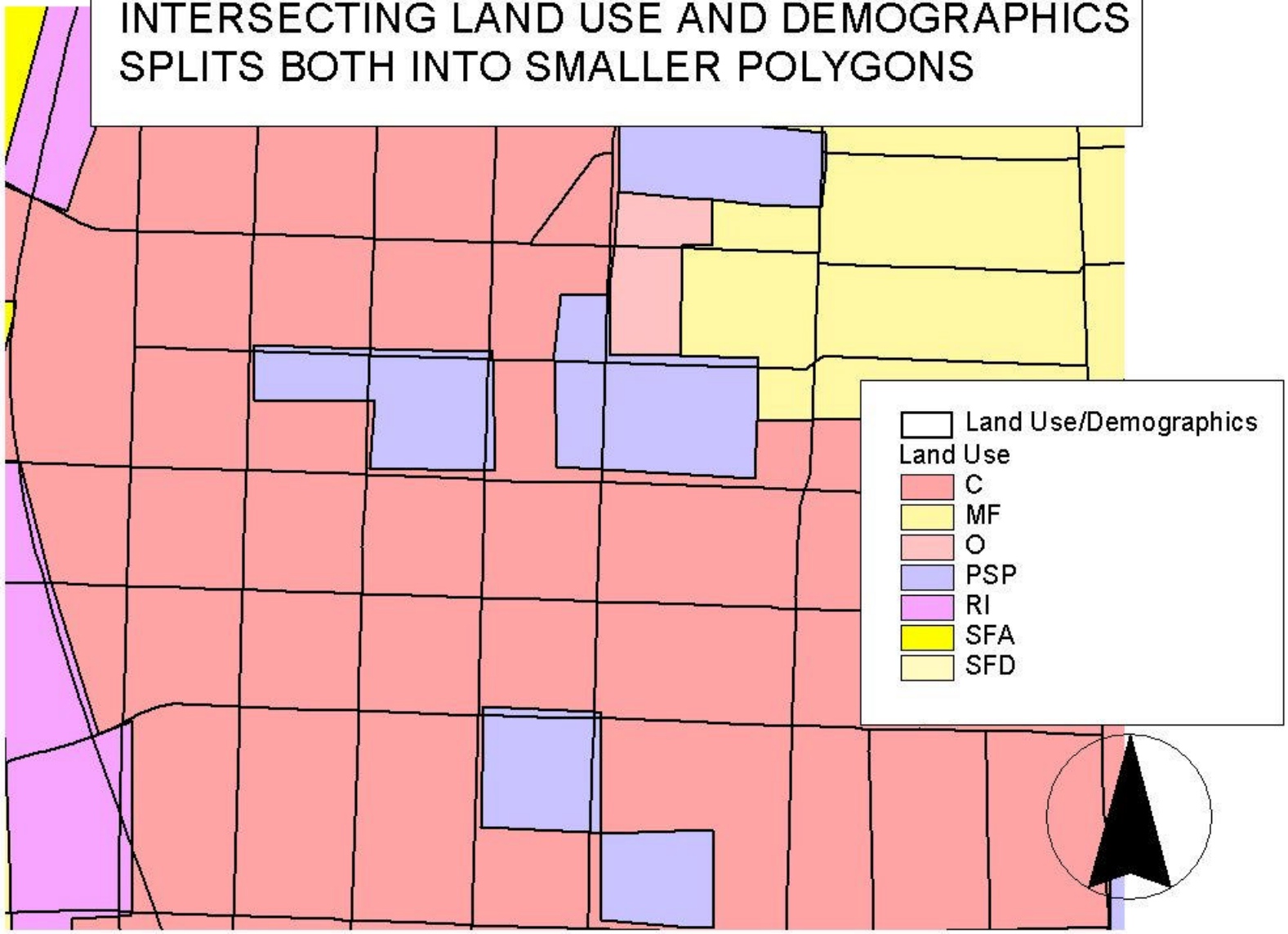
Steps In The Polygon Overlay Technique

- Intersect the demographics coverage with the land use coverage.
- Calculate unit density for each demographics polygon, excluding land uses for which demand is based on other assumptions.
- Intersect the resulting demographics/land use coverage with the service area polygon coverage.

Steps In The Polygon Overlay Technique (continued)

- Restore the population or housing unit count to each polygon by multiplying the density by the area.
- Estimate demand for each polygon based on the specific mathematical relationship between land use and demand. Formulas are supplied for the areas excluded in step 1.
- Finally demand is aggregated by service area polygon.

INTERSECTING LAND USE AND DEMOGRAPHICS SPLITS BOTH INTO SMALLER POLYGONS



Intersecting Land Use and Demographics Splits Both

AREA	TRTBLK	HU	HUDEN	LUCODE	MAXDEN	MAX
165795.01026	4003501	26	6.83109	MF	9.00000	34.25517
137942.22842	4003502	1	0.25837	MF	9.00000	28.50046
30045.72133	4003502	1	0.25837	PSP	0.00000	0.00000
610.11466	4003502	1	0.25837	C	0.00000	0.00000
225288.75332	4003503	56	9.53136	MF	9.00000	46.54726
913.89659	4003503	56	9.53136	PSP	0.00000	0.00000
23247.80352	4003503	56	9.53136	PSP	0.00000	0.00000
6479.57455	4003503	56	9.53136	C	0.00000	0.00000
313246.04718	4003504	33	4.58898	MF	9.00000	64.72026
44274.99753	4003505	19	3.44960	PSP	0.00000	0.00000
195648.32612	4003505	19	3.44960	MF	9.00000	40.42321
459158.47414	4004104	53	4.36734	SFA	30.00000	316.22484
62999.76041	4004104	53	4.36734	SFD	4.00000	5.78510
6465.94118	4004104	53	4.36734	PSP	0.00000	0.00000
257857.40757	4004105	36	5.74676	SFA	30.00000	177.58775
1556.69841	4004105	36	5.74676	MF	9.00000	0.32163
13463.25057	4004105	36	5.74676	MF	9.00000	2.78166
90822.83761	4004107	18	8.19768	SFA	30.00000	62.55016
4823.67856	4004107	18	8.19768	MF	9.00000	0.99663
91946.39224	4004108	14	6.18851	SFA	30.00000	63.32396
5116.06242	4004108	14	6.18851	MF	9.00000	1.05704

Uniform Distribution Assumption

- The simplest approach assumes that the population is uniformly distributed in any given demographics polygon.
- Provided that the polygons are sufficiently small, this will produce acceptable results.
- The total population or housing unit count is effected mostly by rounding errors.

Proportional Distribution Assumption

- Even when demographics polygons are relatively small, they may be split by land use boundaries that represent different allowable maximum population densities.
- The resultant polygons are not actually populated to the same density.
- Also, it may not be true that either or both are populated to their theoretical density.

Proportional Distribution Assumption

- Proportional distribution assumes that the population or housing units are distributed within a given demographics polygon based on the ratio of the actual total to a theoretical value.

- The theoretical value is based solely on the land use.

Example Listing of Land Use Types and Typical Housing Unit Density

Land Use	Housing Unit Density
High Density	30 H.U./Acre
Medium Density	9 H.U./Acre
Low Density	4 H.U./Acre

Formula For Proportioning Demographics

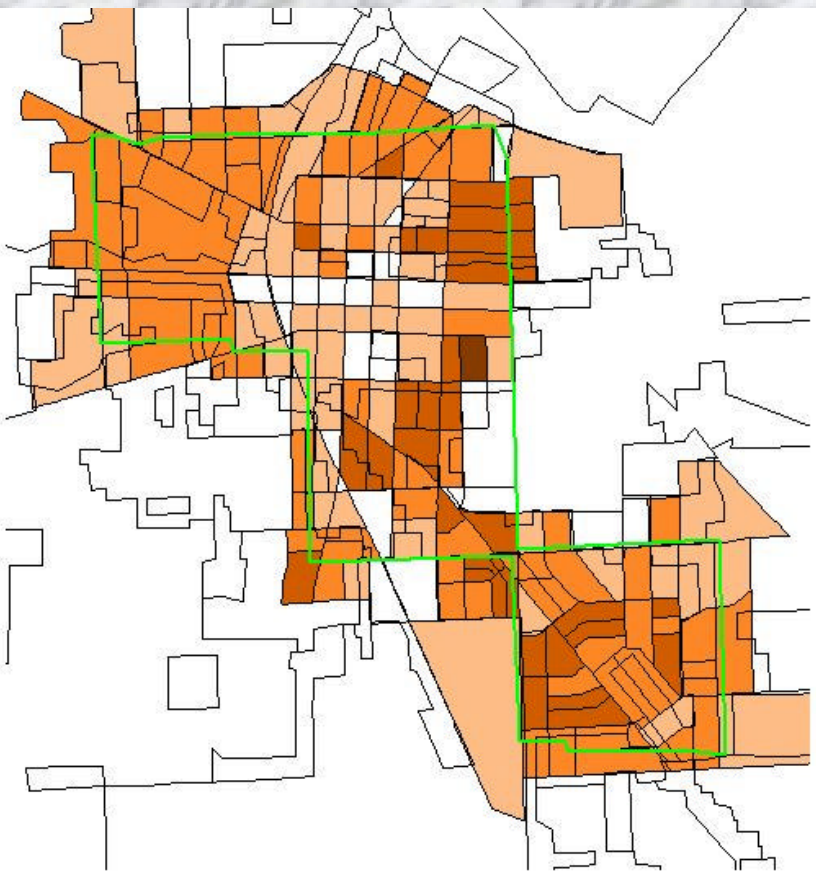
$$RHUD = \frac{MaxDen * HU}{\Sigma\, Max_{demographics\ poly}}$$

RHUD: The Redistributed Housing Unit Density

MaxDen: The Theoretical Housing Unit Density for the Land Use

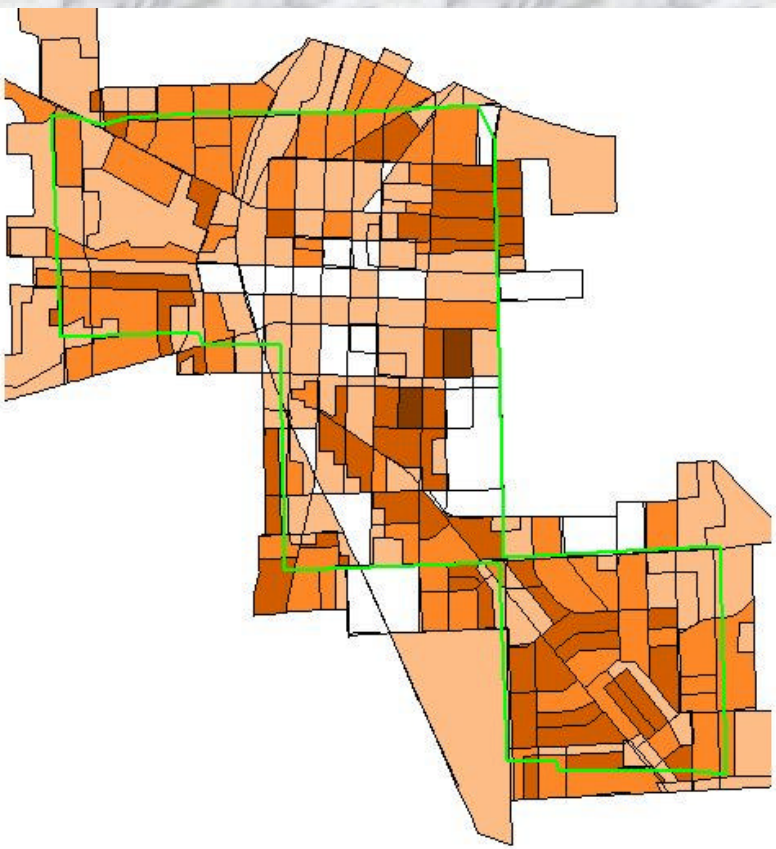
HU: The Housing Unit Count for the entire demographics polygon

$\Sigma\, Max_{demographics\ poly}$: The Sum of the Theoretical Housing Units for the entire demographics polygon



Housing Unit Density
Assuming Uniform Distribution

Pilotarea.shp
Housing Unit Densities
- 0
- 0 - 4
- 4 - 9
- 9 - 30
- 30 - 90



Housing Unit Density
Assuming Proportional Distribution

Study Area
Redistributed H. U. Density
- 0
- 0 - 4
- 4 - 9
- 9 - 30
- 30 - 2700

Summary

- Land use classifications must be custom fit to the analysis. Some areas classified as commercial, industrial, and public also had housing units (12.8%). When these areas were assumed to have theoretical housing unit values of 0, the housing units in these areas were lost.
- The highest resolution demographics coverage available is highly recommended.
- The redistribution was accomplished through artificial means with little actual knowledge of the detailed distribution.