UrbanSim

Simulating Interactions Between Urban Development, Transportation and the Environment

Historical Validation in Eugene-Springfield

Oregon Symposium

Outline of Presentation

- UrbanSim Overview
- Data Integration
- Longitudinal Validation

UrbanSim

Graduate and Undergraduate Research at the University of Washington

- **Computer Science & Engineering**
  Faculty: Alan Borning
  grad students: Michael Noth, Denise Pinnel
  undergrad students: Michael Becke, Matthew Dockrey, Nathan Freier
- **Evans School of Public Affairs**
  Faculty: Paul Waddell
- **Architecture & Urban Planning**
  Faculty: Marina Alberti (Paul Waddell, joint appointment)
  grad students: Erik Botsford, Shannon Winger
- **Civil Engineering**
  Faculty: Scott Rutherford
  grad students: Gudmundur Ulfarsson
- **Economics**
  grad students: Yoram Bauman

UrbanSim Overview

- Application
  - Eugene-Springfield, Oregon
  - Honolulu, Hawaii
  - Salt Lake City, Utah
  - Seattle, Washington
- Funding
  - National Science Foundation
  - National Cooperative Highway Research Program
  - University of Washington
  - Oregon Department of Transportation
  - Governor’s Office, State of Utah
  - Oahu Metropolitan Planning Organization


Linked Urban Markets
Flow of consumption from supplier to consumer
Regulation or Pricing
Governments
Services
Land
Infrastructure
Developers
Housing
Commercial Building
Households
Labor
Businesses

Urban Development is Dynamic

- Not Everyone Moves
  - Moving Transaction costs are significant
  - Household Mobility Varies by Age, Inc.
  - Business Mobility Varies by Size, Sector
- Land Development is Incremental
  - Existing Buildings
  - New Construction
  - Redevelopment
  - Only 2% of stock of real estate is ‘new’
- Processes occur in different time scales

UrbanSim Design Objectives

- Operational Use in Metropolitan Planning/Policy
- Support Analysis of Growth Management Strategies
- Support Strategic Planning for Infrastructure
- Transparent Behavioral Foundation
- Explore Interaction of Markets and Policies
- Analyze Trade-offs between public objectives
  - Efficiency
  - Equity
  - Environmental Impact
- Develop non-proprietary toolbox for urban modeling

Behavioral Representation

- Discrete Choice Framework
  - Household Mobility and Location Choice
  - Business Mobility and Location Choice
  - Developer Land Development/Redevelopment
  - Explicit Markets for Real Estate
- Governmental policies exogenous: scenarios
- Dynamic
  - Path-dependent (history matters)
  - Supply fixed in short run (one year)
  - Adjustment toward equilibrium in long-run
  - Annual time steps

Key Features of the Model

- Simulates Decisions of Urban Actors
- Explicit Representation of:
  - Land, Buildings and Occupants
  - Land Market and Prices
  - Government Policy and Infrastructure
- High Spatial, Sector Disaggregation
- Based on Random Utility Theory

Data Requirements

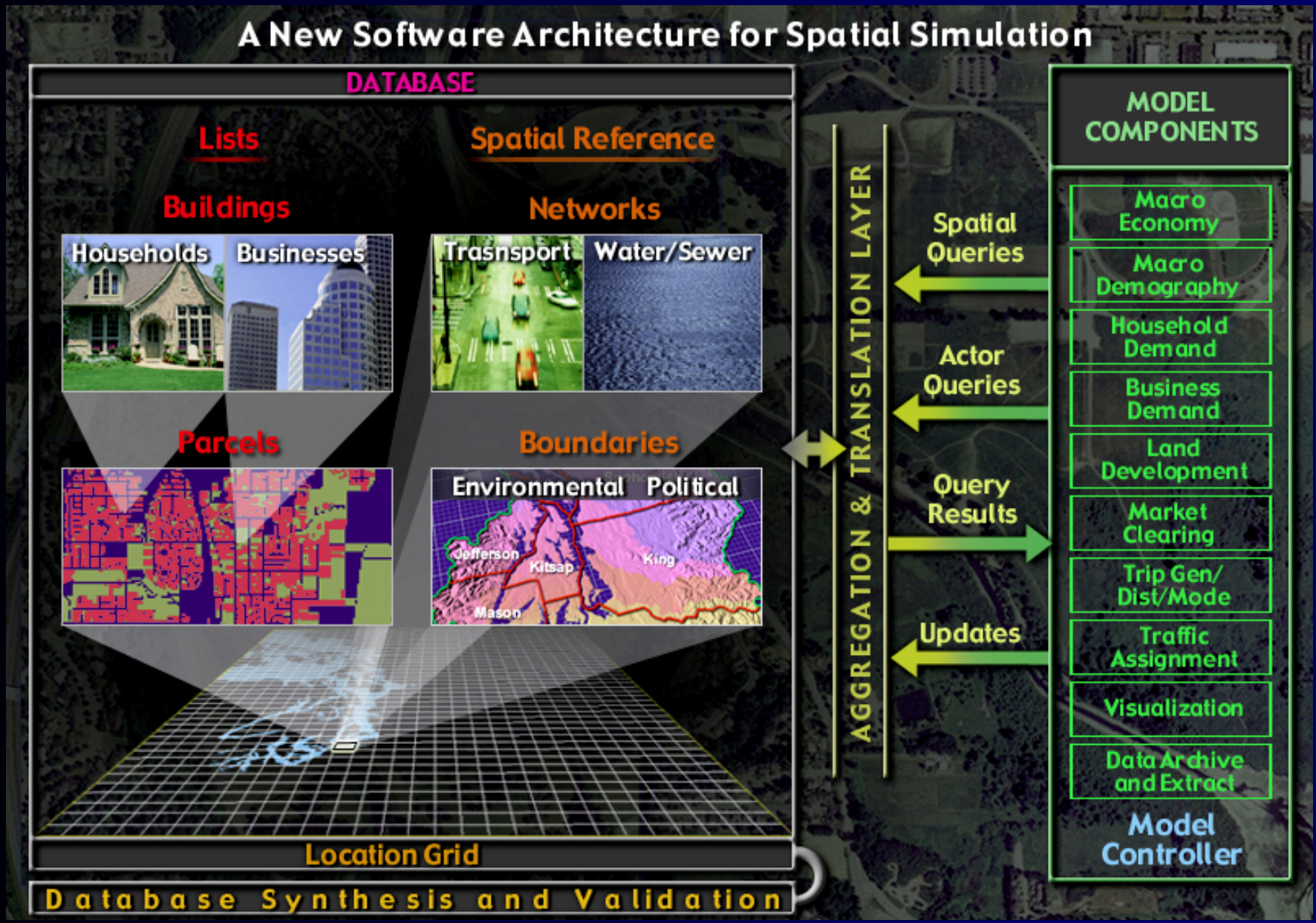
- Regional Control Totals
- Parcel Data
- Business Establishments
- Household Data (Census, Travel Survey)
- Land Use Plan
- Environmental Constraints
- Development Costs

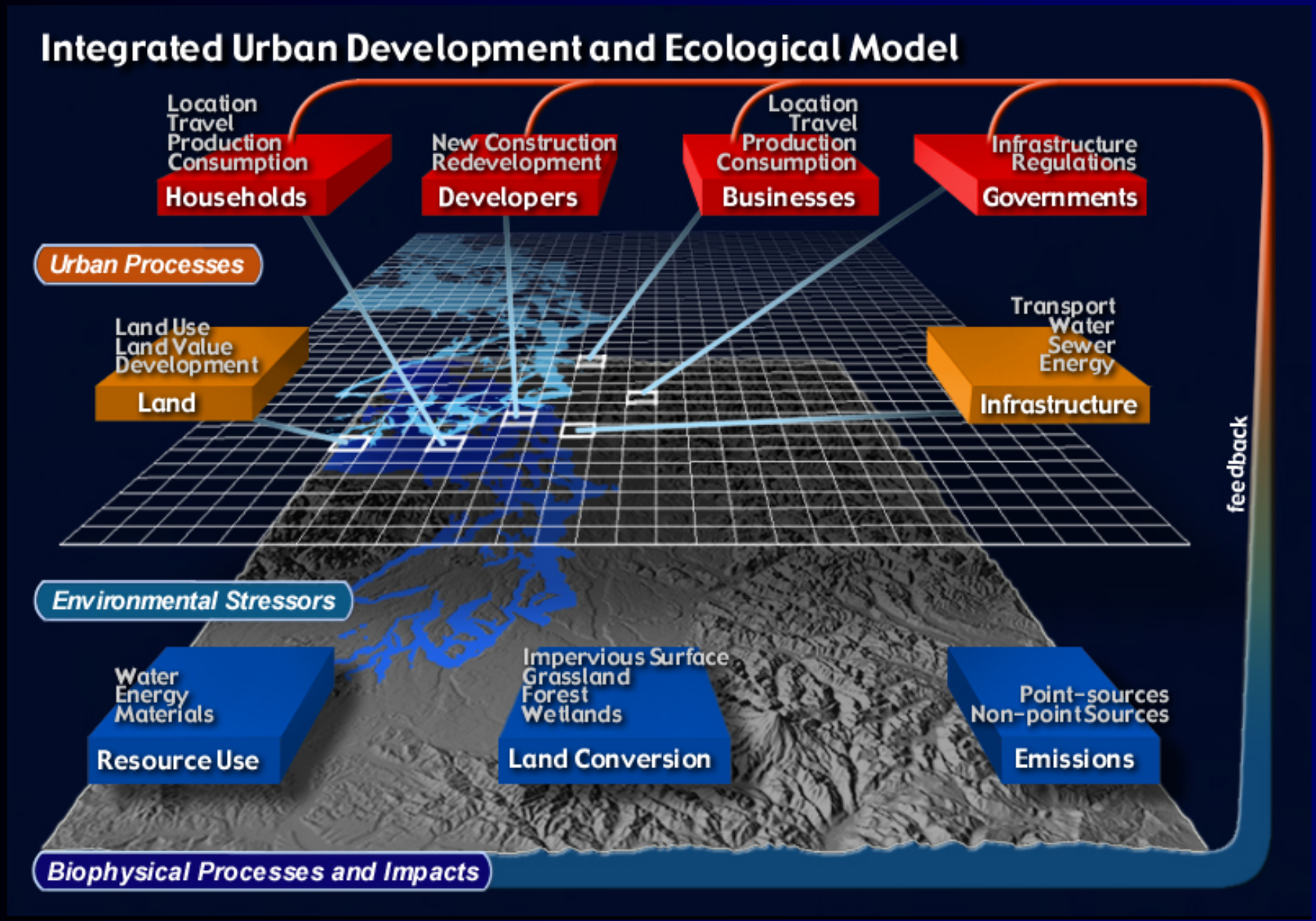
Outputs

- Population and Households by Type
  - Income
  - Age
  - Household Size
  - Children
  - Workers
- Employment by Industry Sector
- Housing Units, Commercial Square Feet, Prices by Type
- All outputs by grid cell and by zone

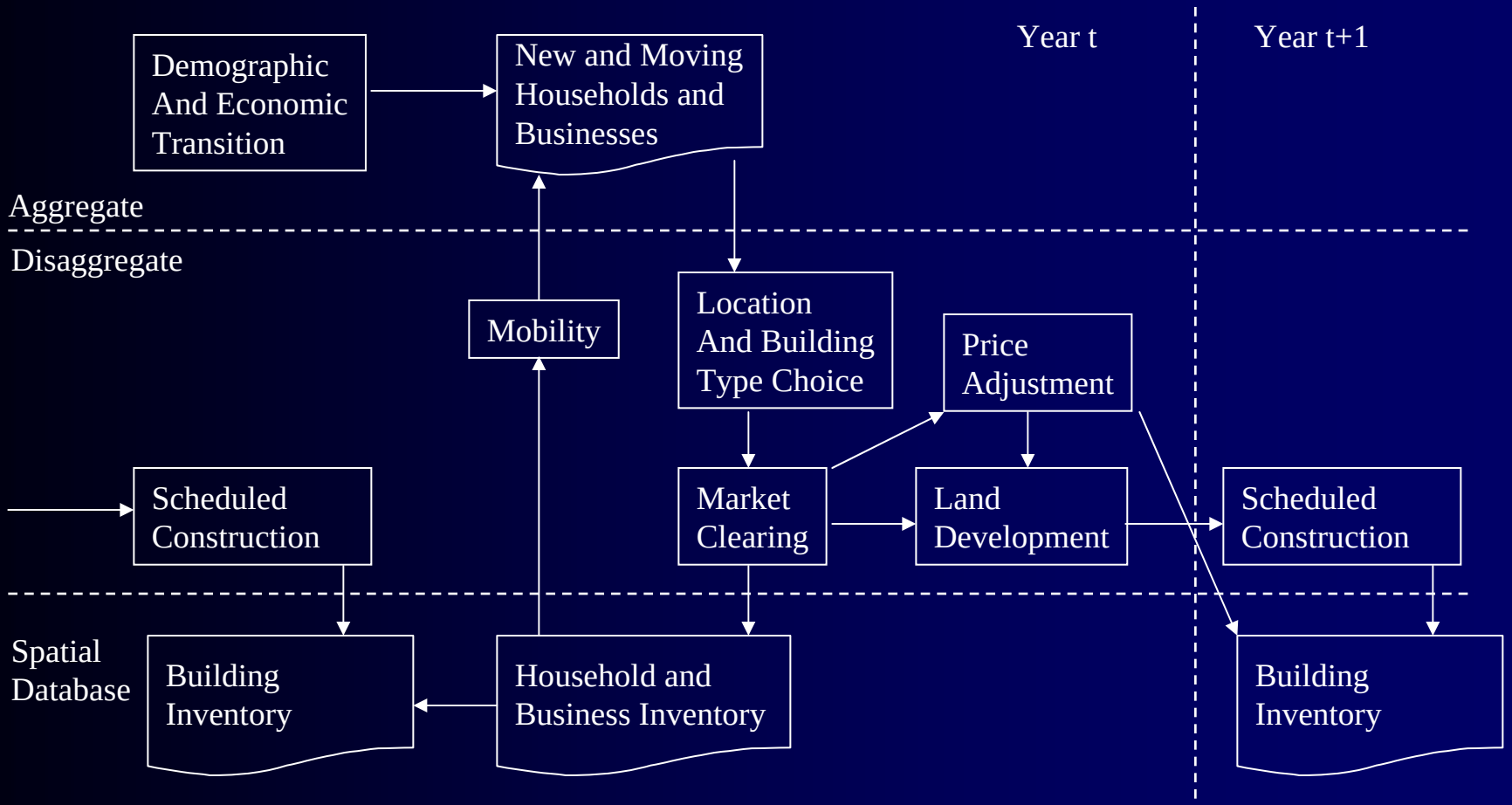
Current Implementation

- Implemented in Java
- New Architecture for Spatial Simulation
  - Reusable Components
  - Variation in Spatial, Temporal and Behavioral Resolution
- Open Software: GNU General Public License
- Visualization Architecture
- 150 meter grid cell unit of analysis


A New Software Architecture for Spatial Simulation
DATABASE
Lists
Spatial Reference
Buildings
Networks
Households
Businesses
Trasnsport
Water/Sewer
Parcels
Boundaries
Environmental
Political
Jefferson
Kitsap
King
Mason
Location Grid
Database Synthesis and Validation
AGGREGATION & TRANSLATION LAYER
Spatial Queries
Actor Queries
Query Results
Updates
MODEL COMPONENTS
Macro Economy
Macro Demography
Household Demand
Business Demand
Land Development
Market Clearing
Trip Gen/ Dist/Mode
Traffic Assignment
Visualization
Data Archive and Extract
Model Controller


Integrated Urban Development and Ecological Model
Location
Travel
Production
Consumption
Households
New Construction
Redevelopment
Developers
Location
Travel
Production
Consumption
Businesses
Infrastructure
Regulations
Governments
Urban Processes
Land Use
Land Value
Development
Land
Transport
Water
Sewer
Energy
Infrastructure
feedback
Environmental Stressors
Water
Energy
Materials
Resource Use
Impervious Surface
Grassland
Forest
Wetlands
Land Conversion
Point-sources
Non-point Sources
Emissions
Biophysical Processes and Impacts

UrbanSim Structure and Dynamics



Key Model Components

- Household and Employment Location
  - Standard multinomial logit
  - Grid cell is unit of choice
- Real Estate Development
  - Multinomial logit
  - 24 development type outcomes
- Real Estate Price Estimation
  - Hedonic regression

Residential Location Variables

- Housing Characteristics
  - Prices (interacted with income)
  - Development types (density, land use mix)
  - Housing age
- Regional accessibility
  - Job accessibility by auto-ownership group
  - Travel time to CBD and airport
- Urban design-scale (local accessibility)
  - Neighborhood land use mix and density
  - Neighborhood employment

Employment Location Variables

- Real Estate Characteristics
  - Prices
  - Development type (land use mix, density)
- Regional accessibility
  - Access to population
  - Travel time to CBD, airport
- Urban design-scale
  - Proximity to highway, arterials
  - Local agglomeration economies within & between sectors: center formation

Development Variables

- Site characteristics
  - Existing development characteristics
  - Land use plan
  - Environmental constraints
- Urban design-scale
  - Proximity to highway and arterials
  - Proximity to existing development
  - Neighborhood land use mix and property values
  - Recent development in neighborhood
- Regional
  - Access to population and employment
  - Travel time to CBD, airport
- Vacancy rates

Land Price Variables

- Site characteristics
  - Development type
  - Land use plan
  - Environmental constraints
- Regional accessibility
  - Access to population and employment
- Urban design-scale
  - Land use mix and density
  - Proximity to highway and arterials
- Vacancy rates

Travel Model Interface

- Supports travel models through ASCII file exchange
- Supports Interactive Analysis With Travel Models
- Accessibility from Travel Models
  - Composite Utility from Mode Choice Models
  - Activity Distribution at Destinations

Accessibility Index

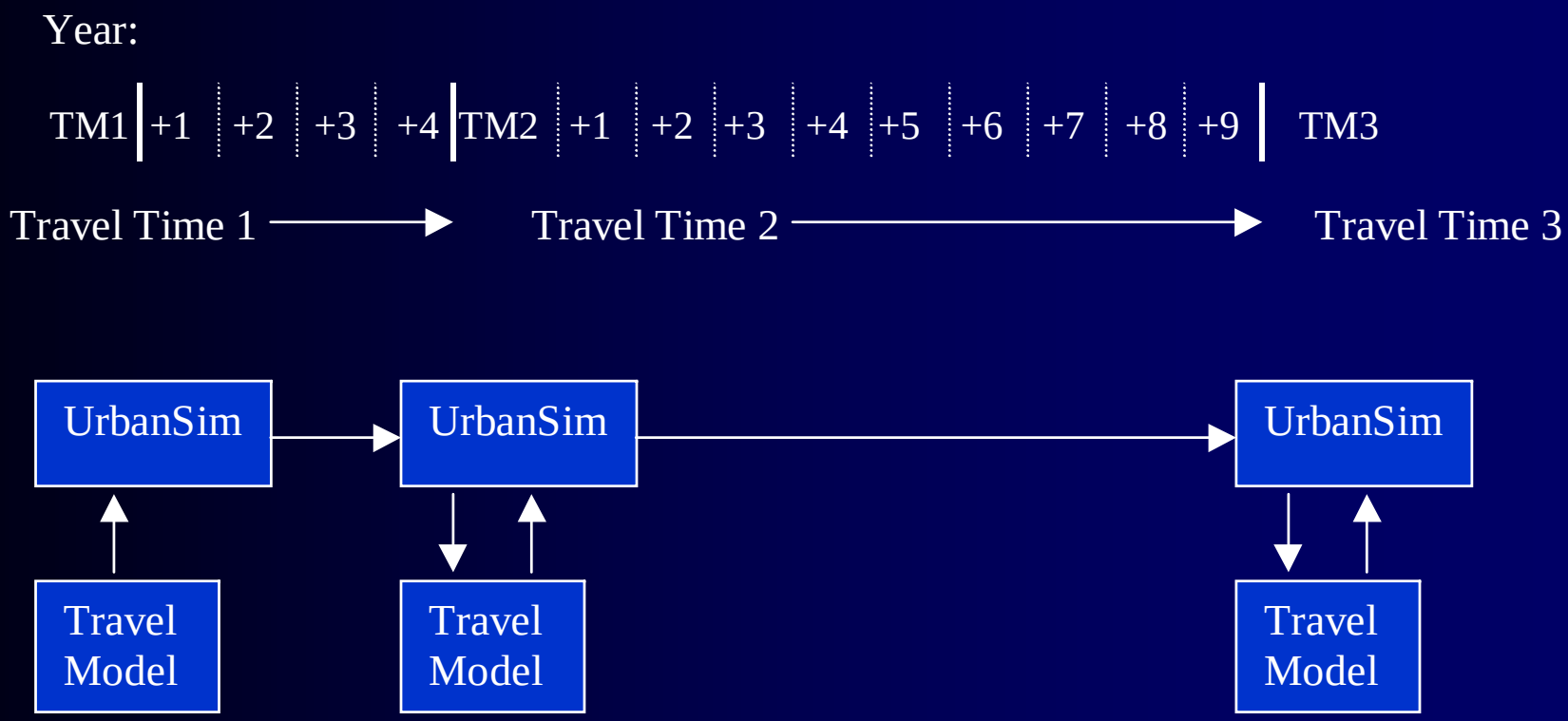
$$Access_i = \sum_j^J A_j e^{\beta L_{ij}}$$

A_j is the quantity of activity in location j

L_{ij} is composite utility, or logsum (for one car households), from location i to j from Mode Choice Model.

β is the utility scaling parameter, initially set to 1

Interaction With Travel Models



(TM = Travel Model Year)

Growth Management Policies

- Land Use Plans
- Environmental Constraints
  - Slope
  - Floodplan
  - Wetlands
  - Stream buffers
  - Fault Zones
  - Slide Zones
- Density Constraints (minimum and maximum)
- Urban Growth Boundaries

Evolution of UrbanSim

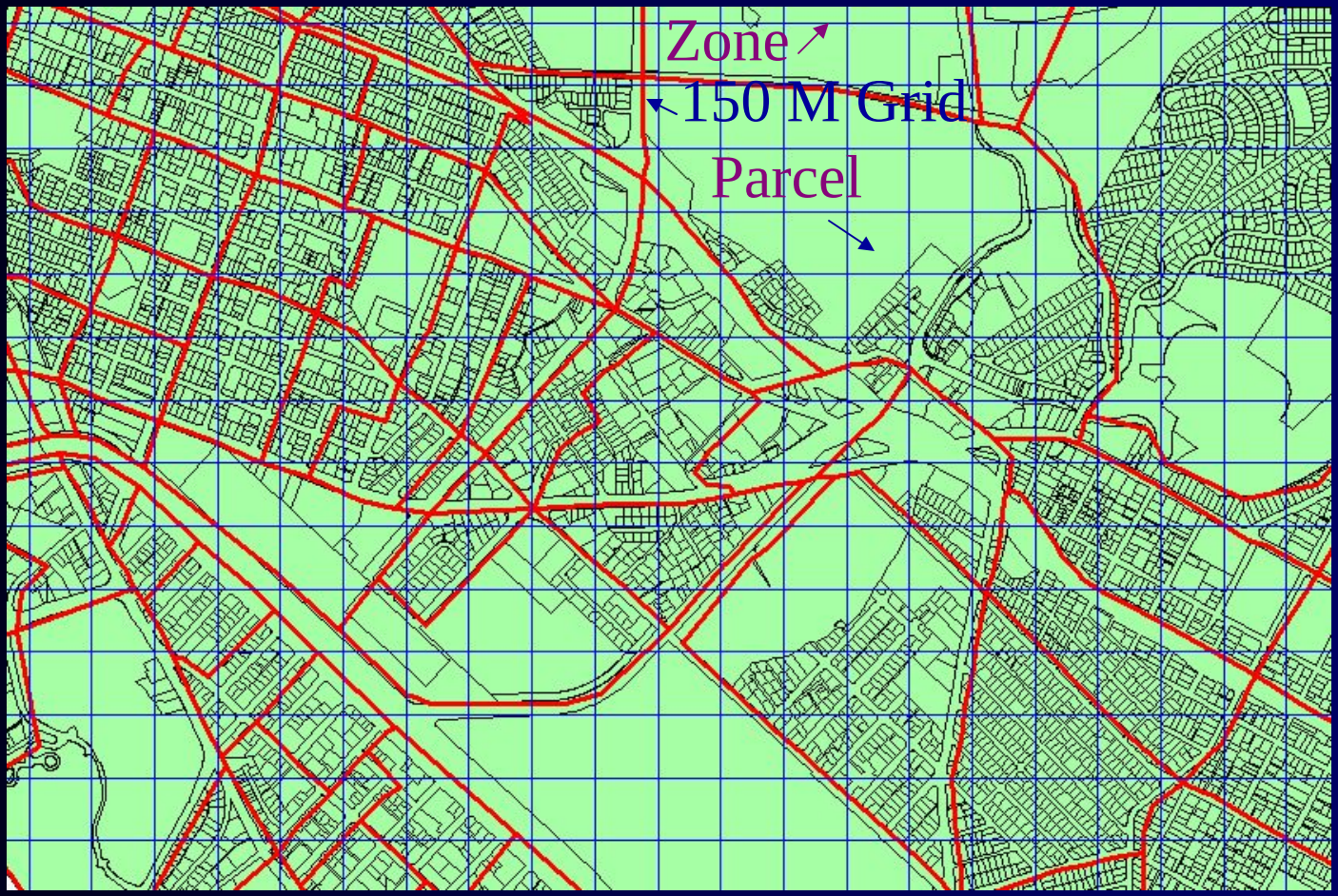
Characteristic	Prototype	Version 1.0
Spatial Unit		
Location	Zone	Grid Cell
Development	Parcel	Grid Cell
Spatial Analysis	None	Spatial Queries
Development	Deterministic	Logit
Visualization	None	Prototype
Aggregation	Aggregate	Microsimulation

Application to Eugene-Springfield

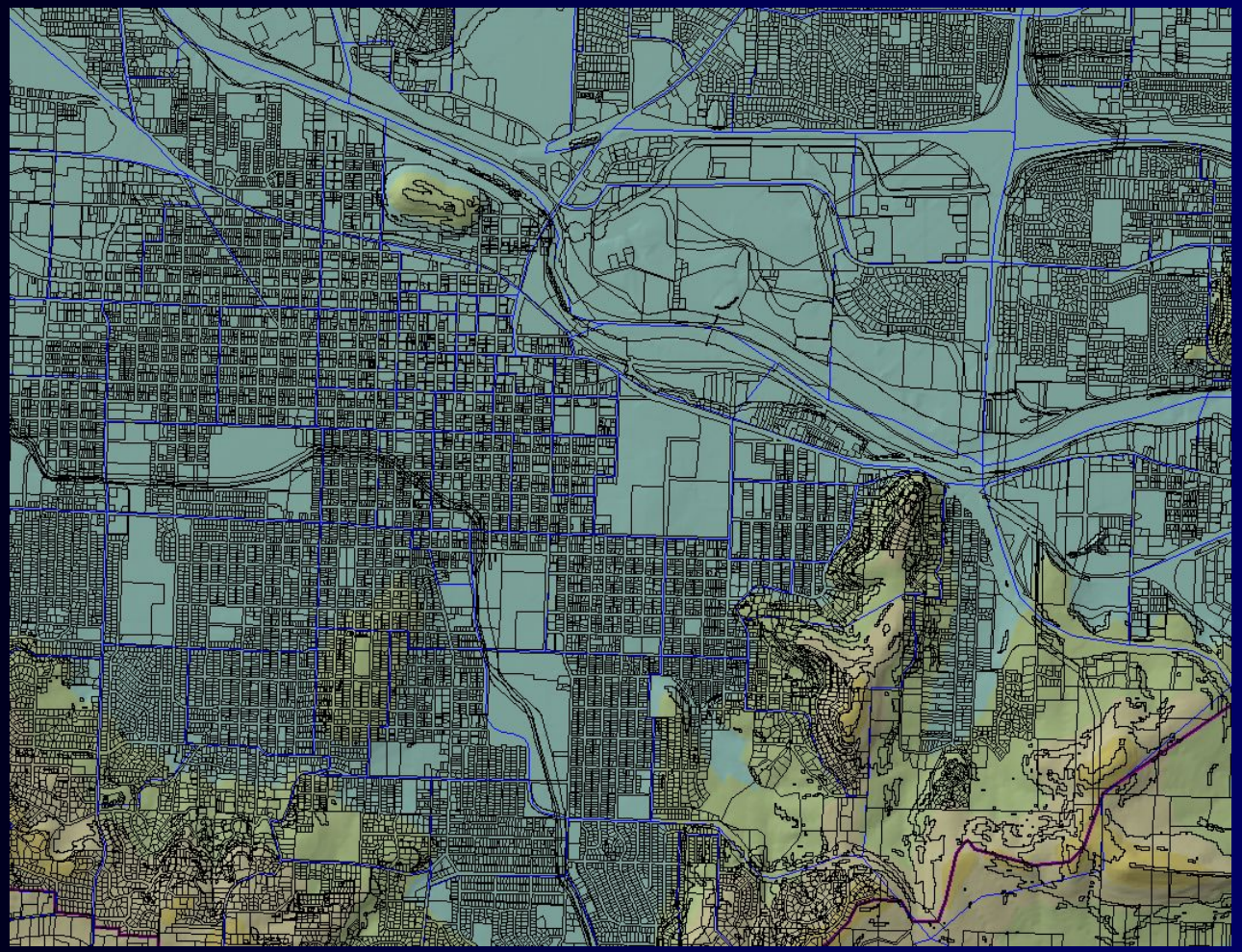
Data Integration and Synthesis

- Integration of 1980 and 1994 Parcels
- 1980 and 1994 Employment
- Synthesis of Missing and Inconsistent Data
  - Parcel Data: Fill Missing Data from Surrounding Parcels
  - Business Matching: Build Space or Move
  - Household Matching: Build or Move

Spatial Units for Analysis



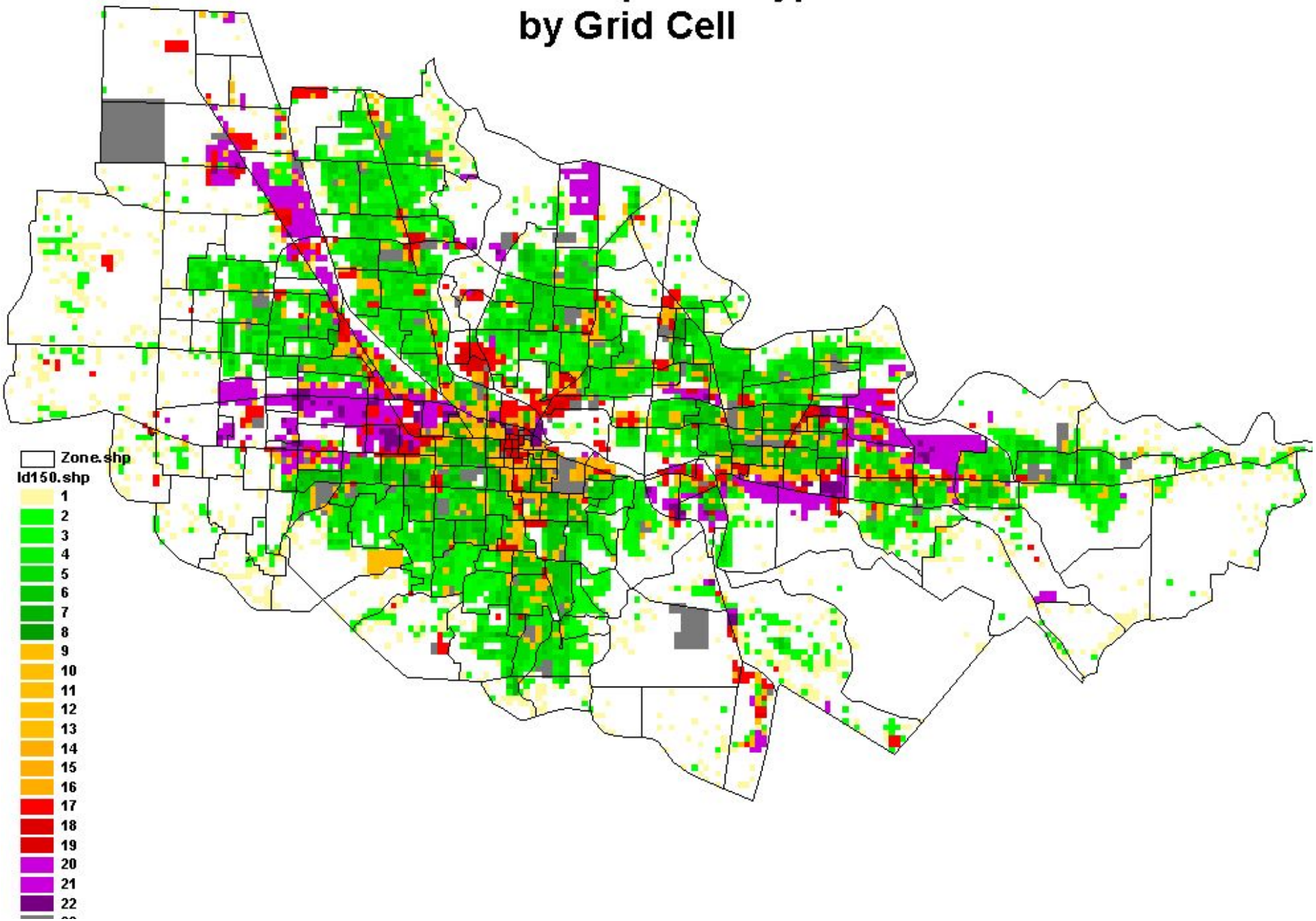
Input Data: Parcels



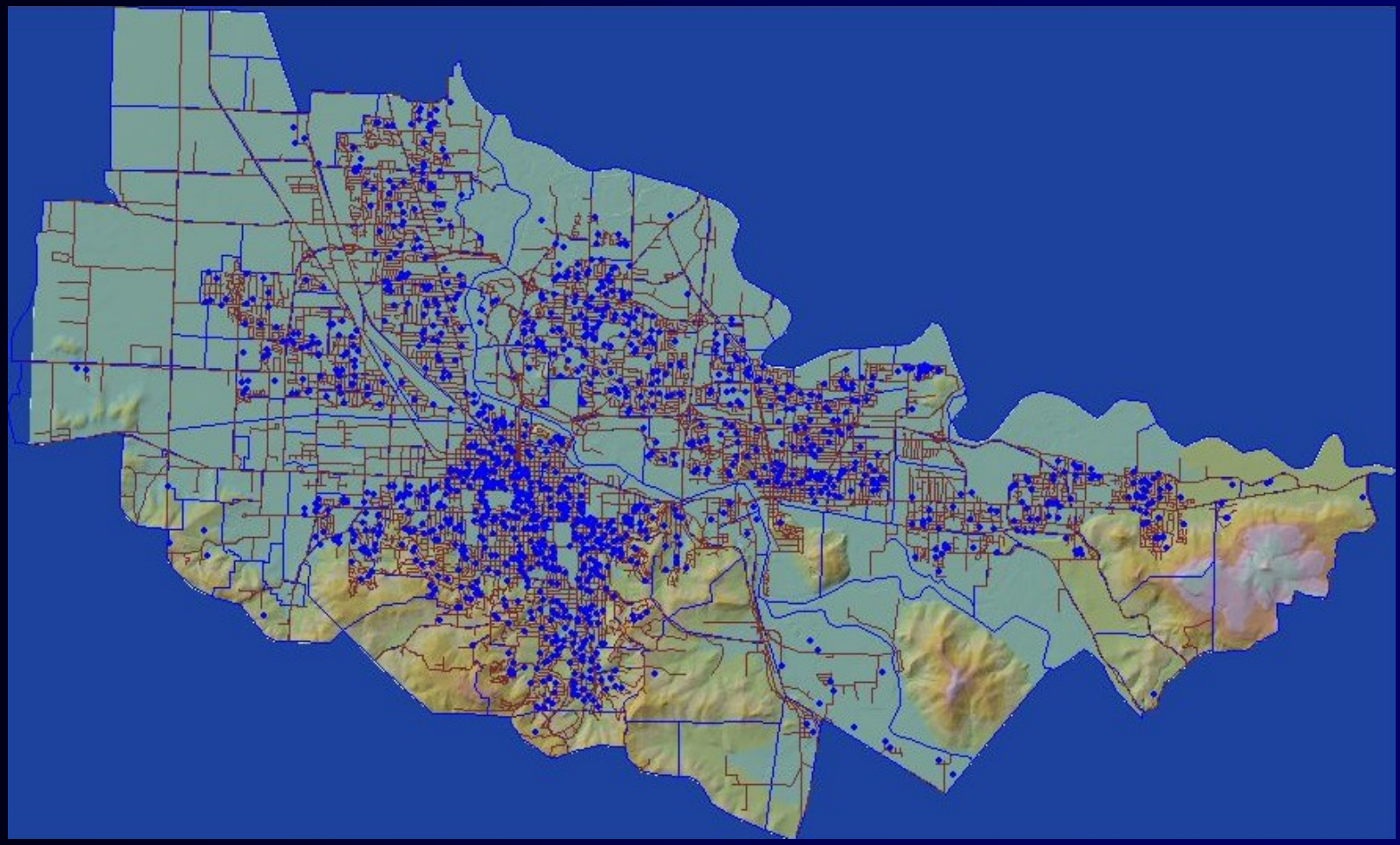
Development Types

Devtype	Name	UnitsLow	UnitsHi	SqftLow	SqftHi	PrimaryUse
1	R1	1	1	0	999	Residential
2	R2	2	4	0	999	Residential
3	R3	5	9	0	999	Residential
4	R4	10	14	0	2499	Residential
5	R5	15	21	0	2499	Residential
6	R6	22	30	0	2499	Residential
7	R7	31	75	0	4999	Residential
8	R8	76	65000	0	4999	Residential
9	M1	1	9	1000	4999	Mixed_R/C
10	M2	10	34	2500	4999	Mixed_R/C
11	M3	10	34	5000	24999	Mixed_R/C
12	M4	10	34	25000	49999	Mixed_R/C
13	M5	10	34	50000	9999999	Mixed_R/C
14	M6	31	65000	5000	24999	Mixed_R/C
15	M7	31	65000	25000	49999	Mixed_R/C
16	M8	31	65000	50000	9999999	Mixed_R/C
17	C1	0	9	1000	24999	Commercial
18	C2	0	9	25000	49999	Commercial
19	C3	0	9	50000	9999999	Commercial
20	I1	0	9	1000	24999	Industrial
21	I2	0	9	25000	49999	Industrial
22	I3	0	9	50000	9999999	Industrial
23	GV	0	9	1000	9999999	Government
24	VacantDev	0	0	0	0	VacantDevelopable
25	Undevelopa	0	0	0	0	Undevelopable

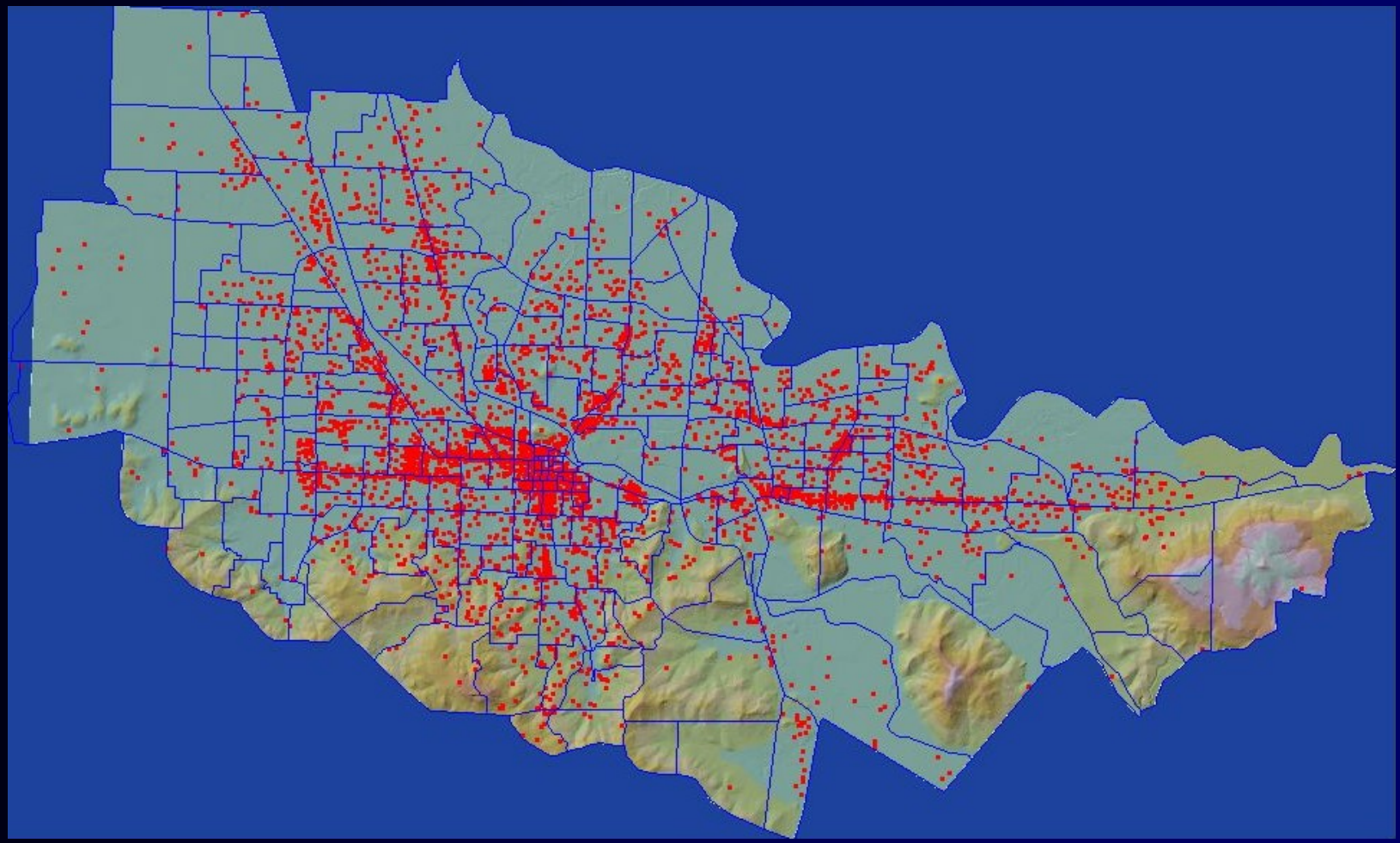
1994 Development Types by Grid Cell



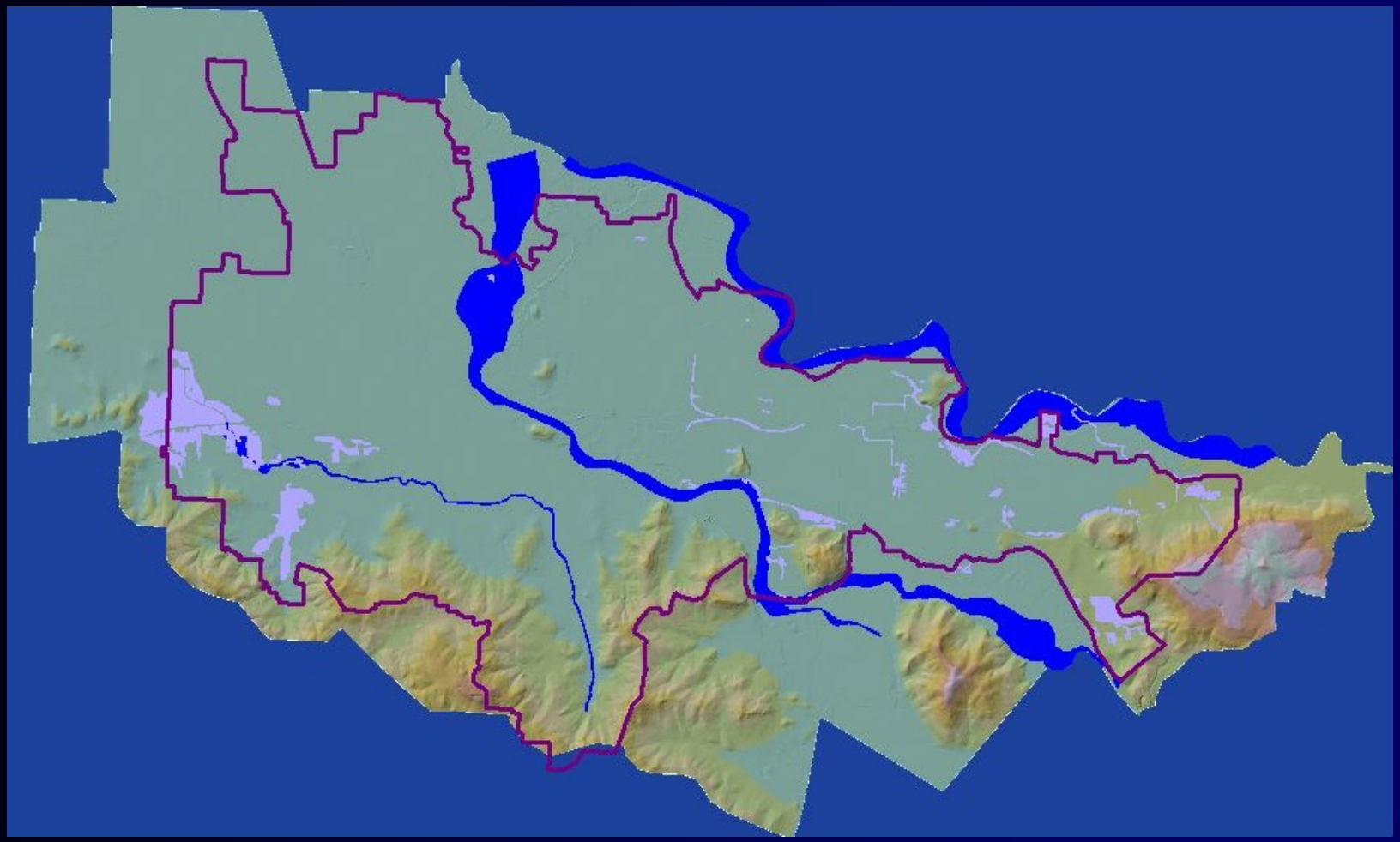
Input Data: Household Travel Survey



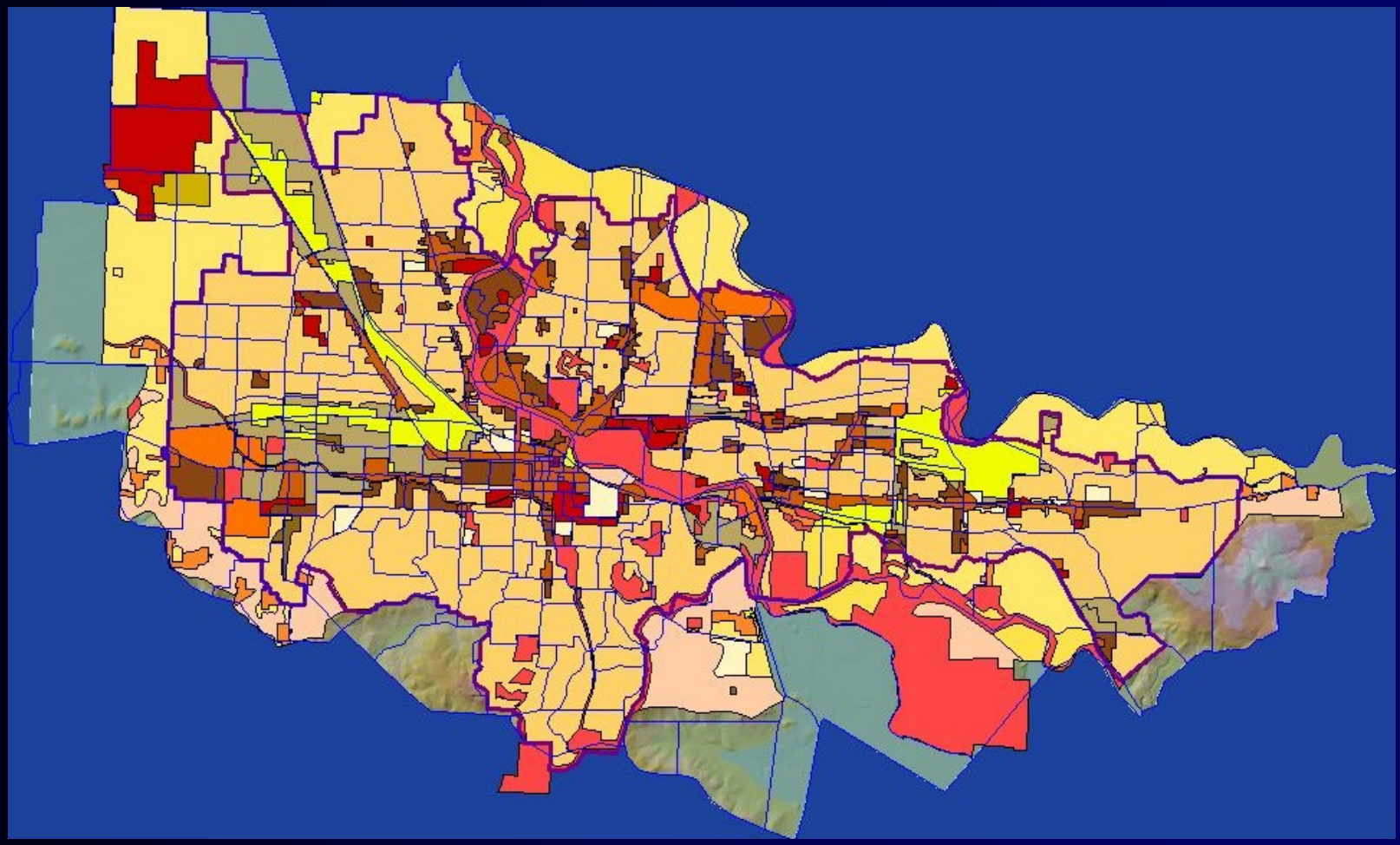
Input Data: Employment



Input Data: UGB and Environmental

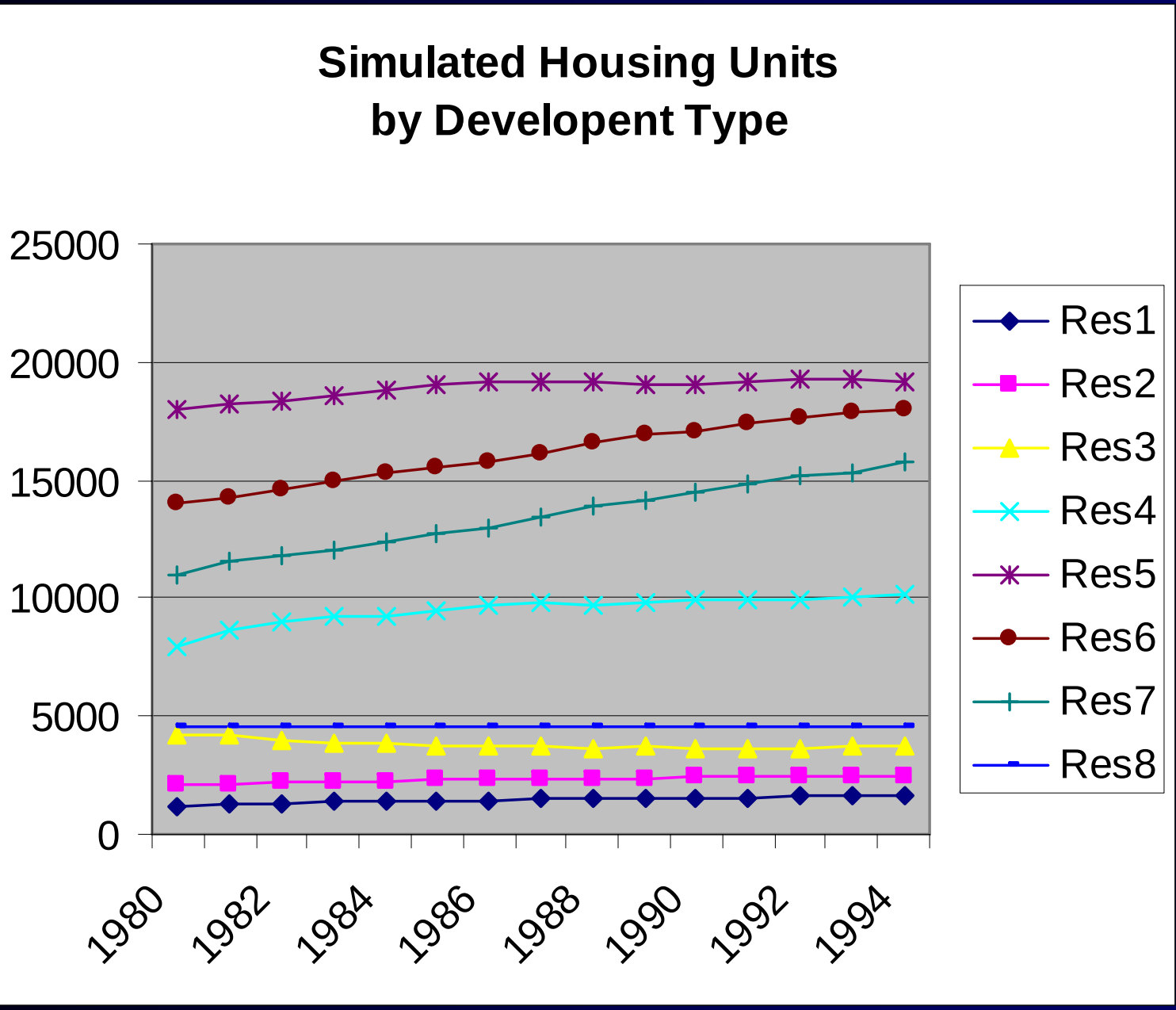


Input Data: Land Use Plan

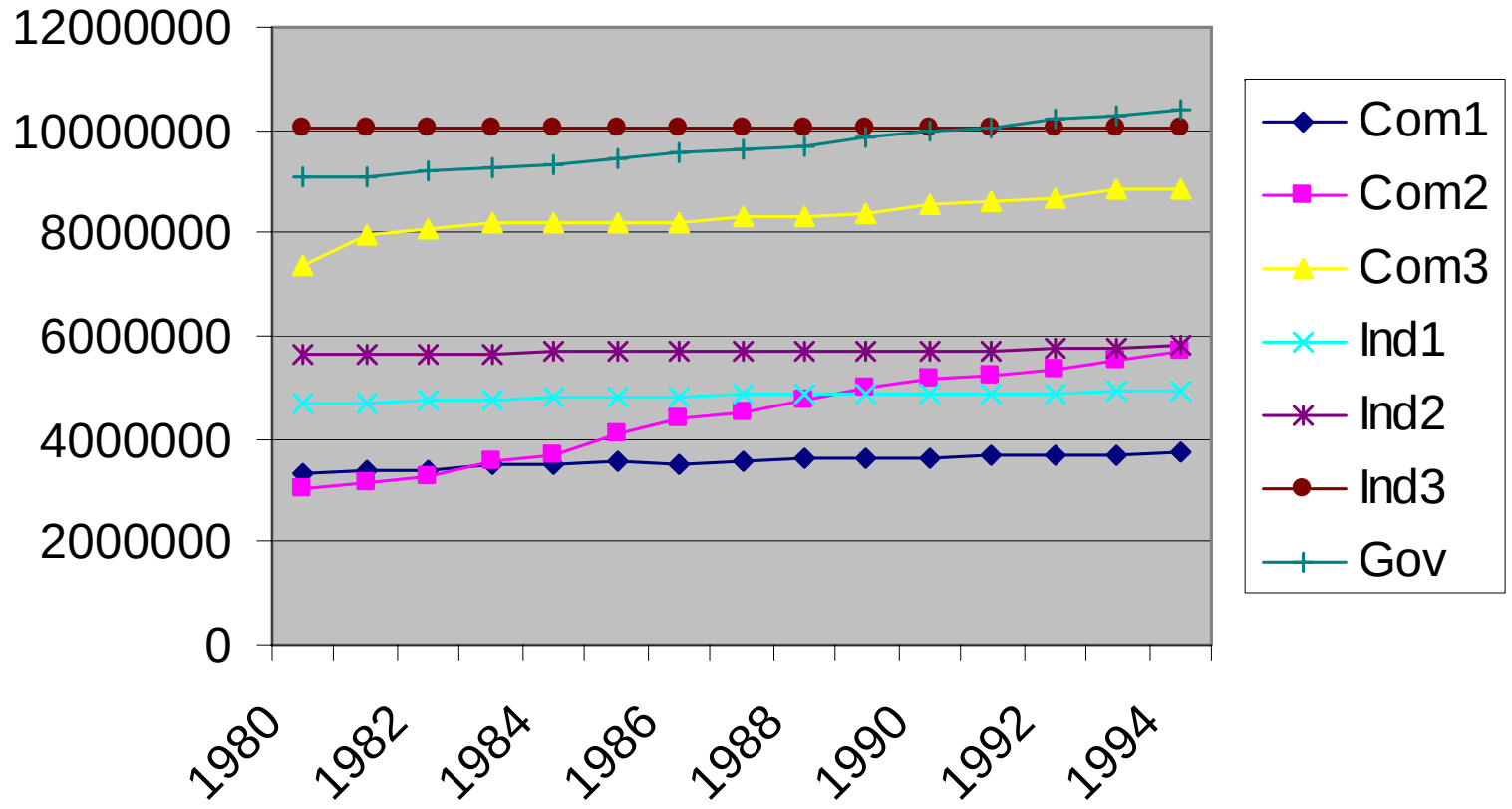


Longitudinal Validation

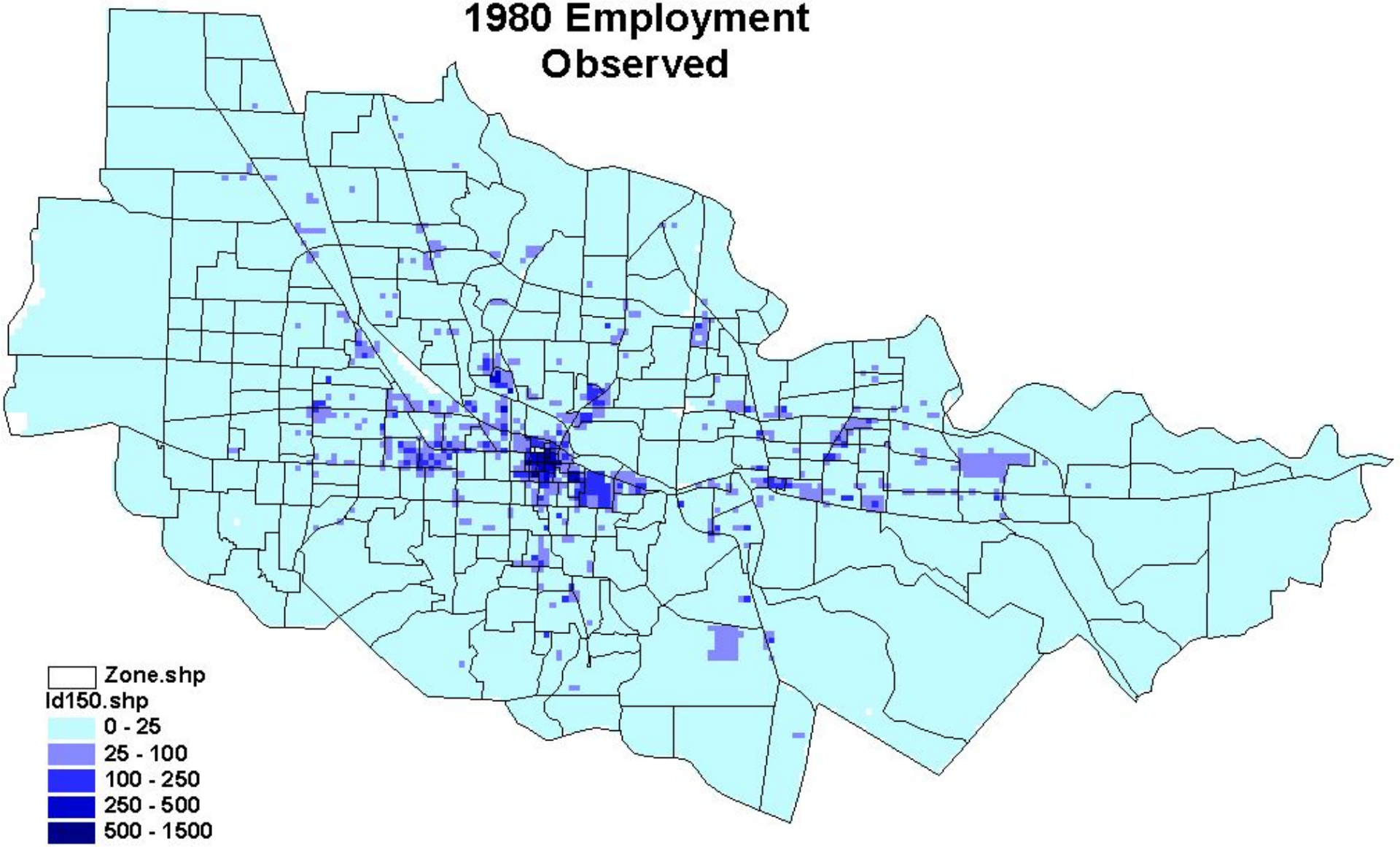
- Based on Version 1.0
- 1980 to 1994
- Estimated coefficients without adjustment
- Constraint on development
  - Wetlands
  - Floodplain
  - Steep slopes
  - UGB


Simulated Housing Units
by Developent Type
25000
20000
15000
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
Res1
Res2
Res3
Res4
Res5
Res6
Res7
Res8

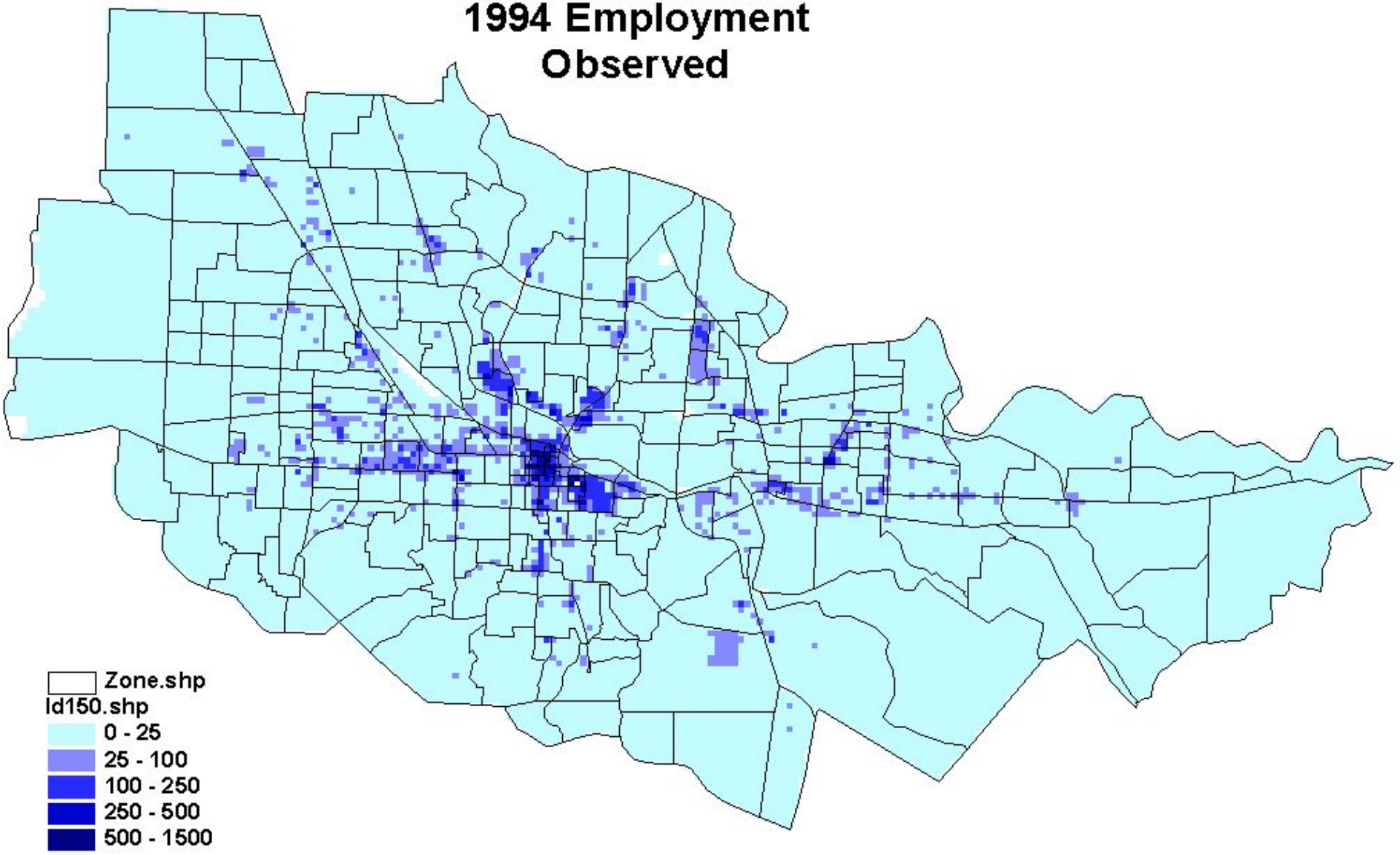
Simulated Nonresidential Sqft by Development Type

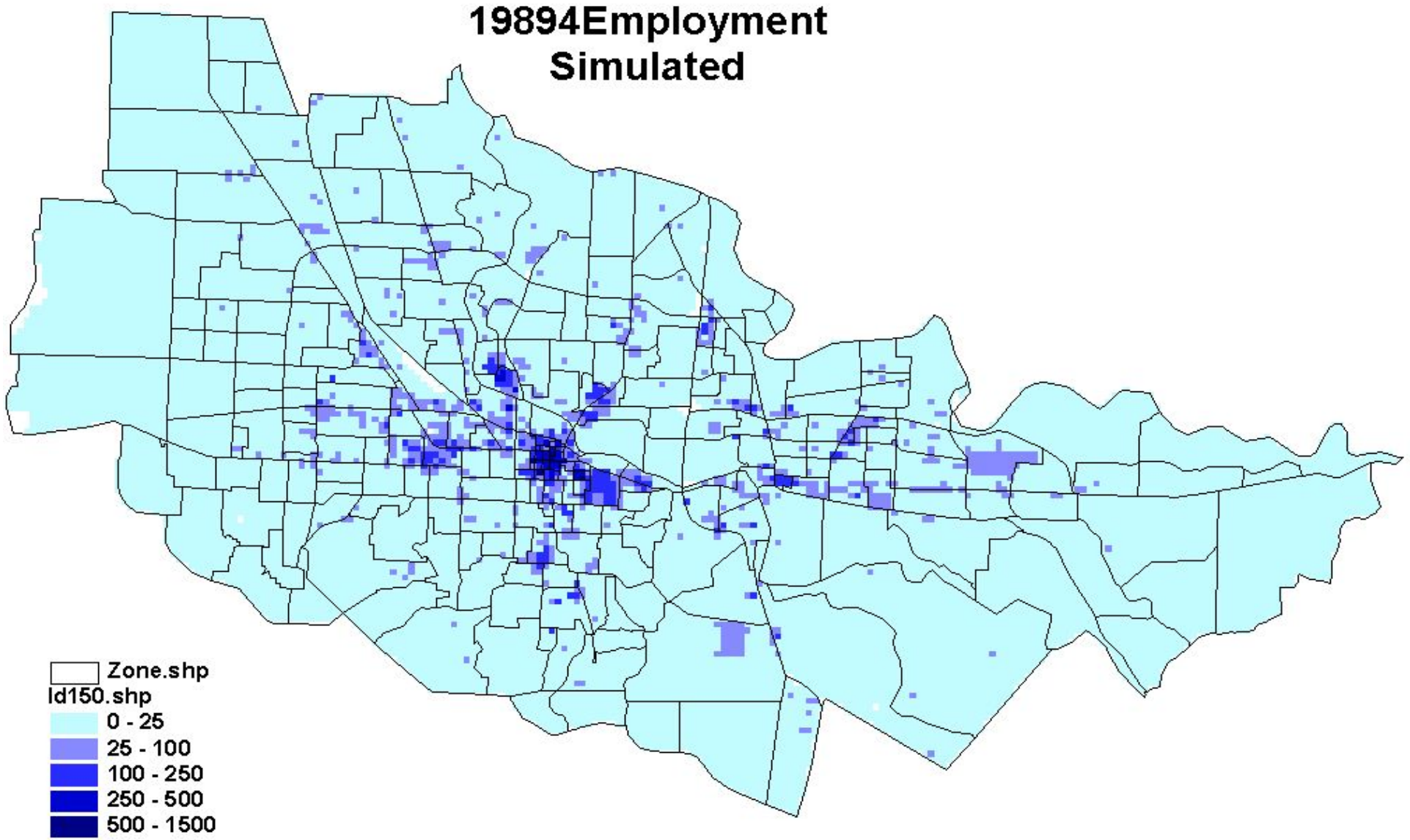


1980 Employment Observed

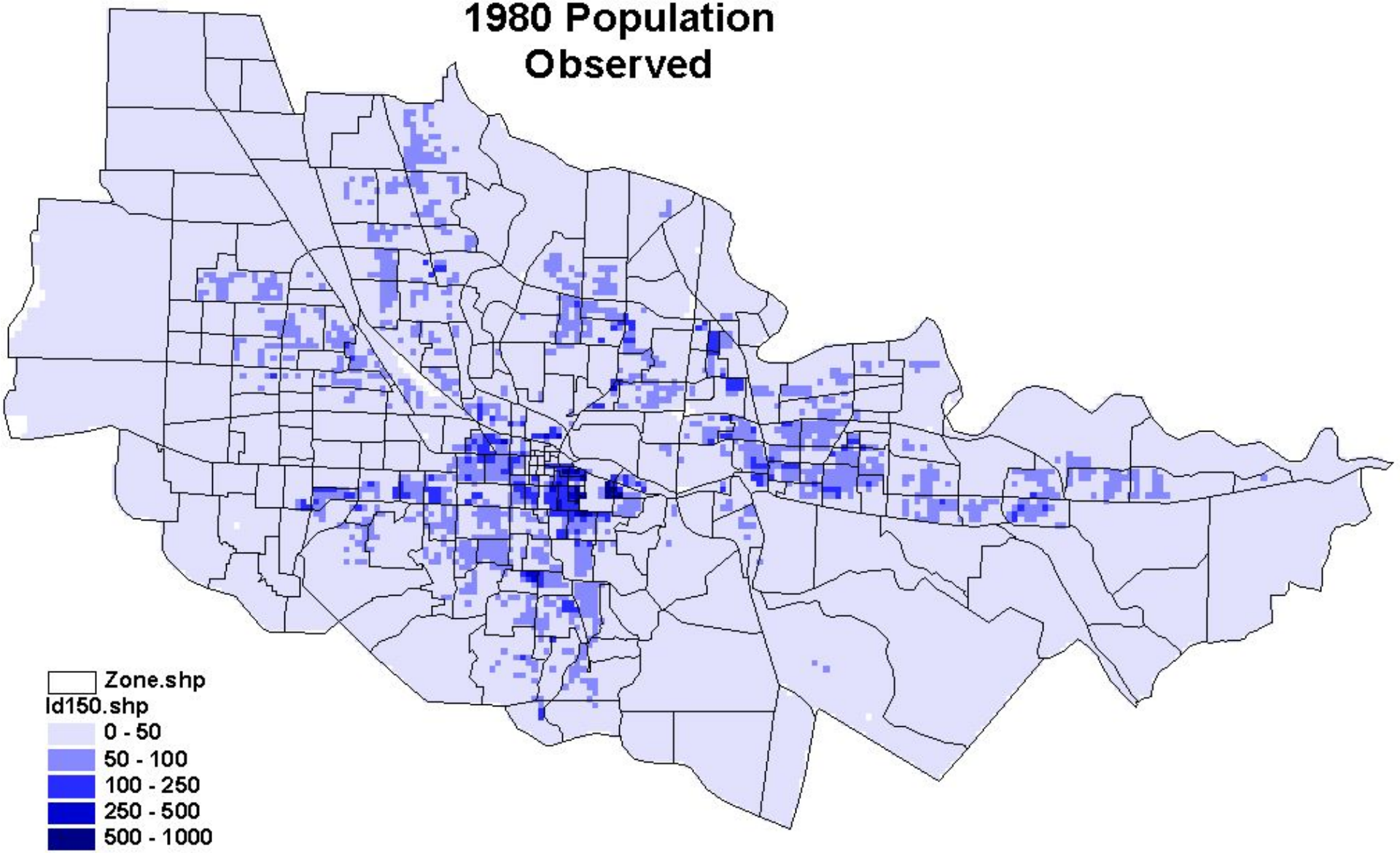


1994 Employment Observed

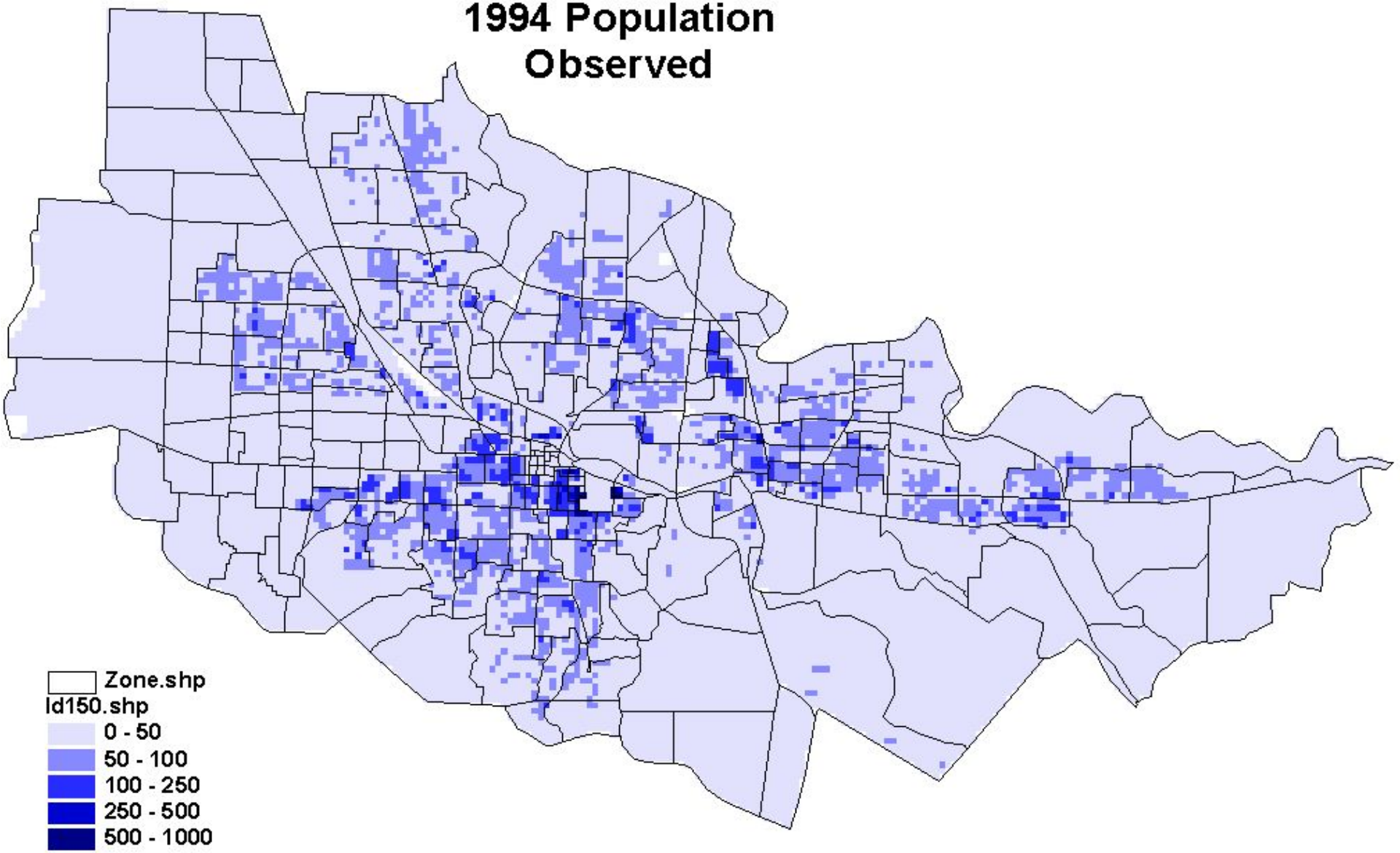



19894Employment
Simulated
Zone.shp
ld150.shp
0 - 25
25 - 100
100 - 250
250 - 500
500 - 1500

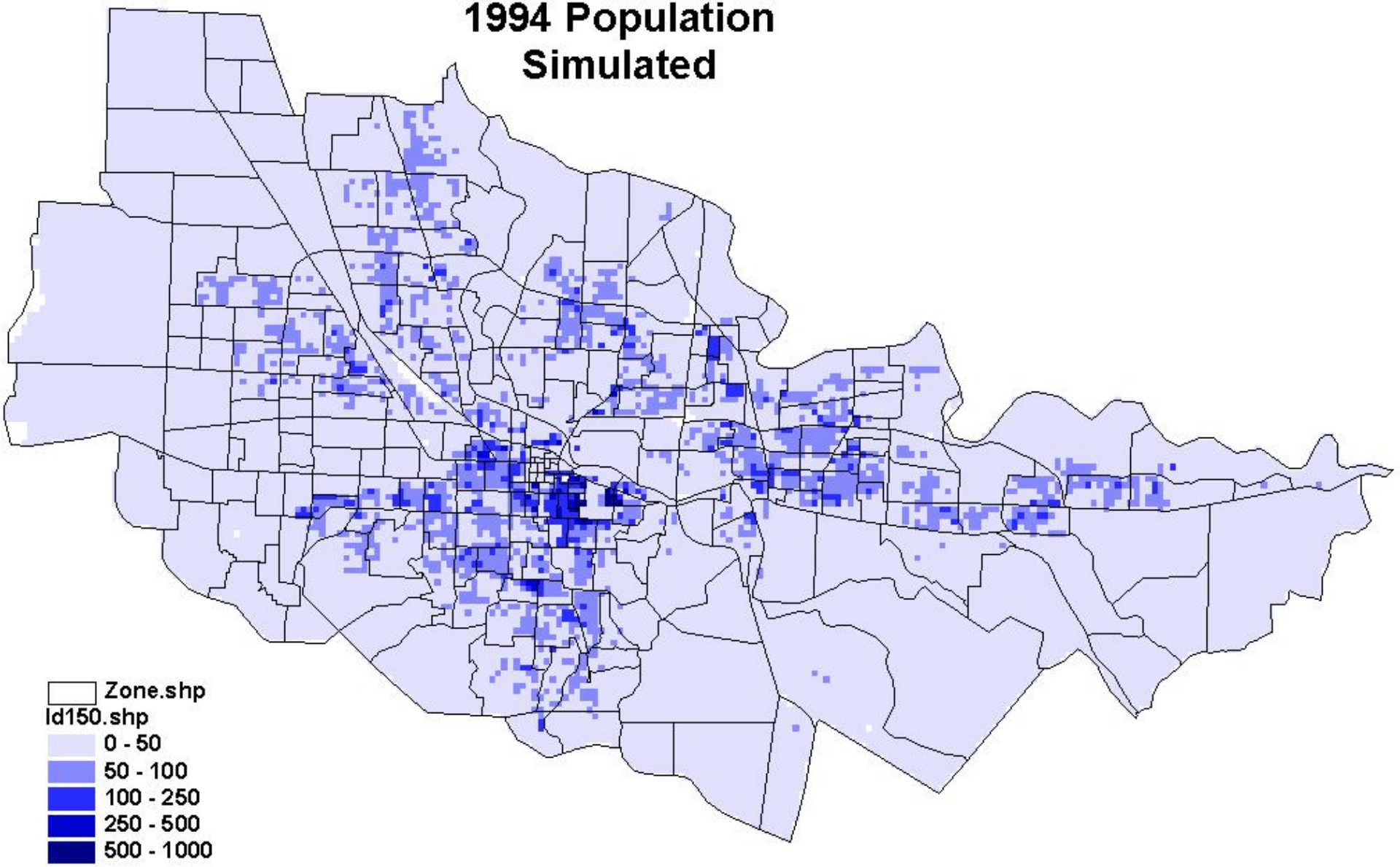
1980 Population Observed



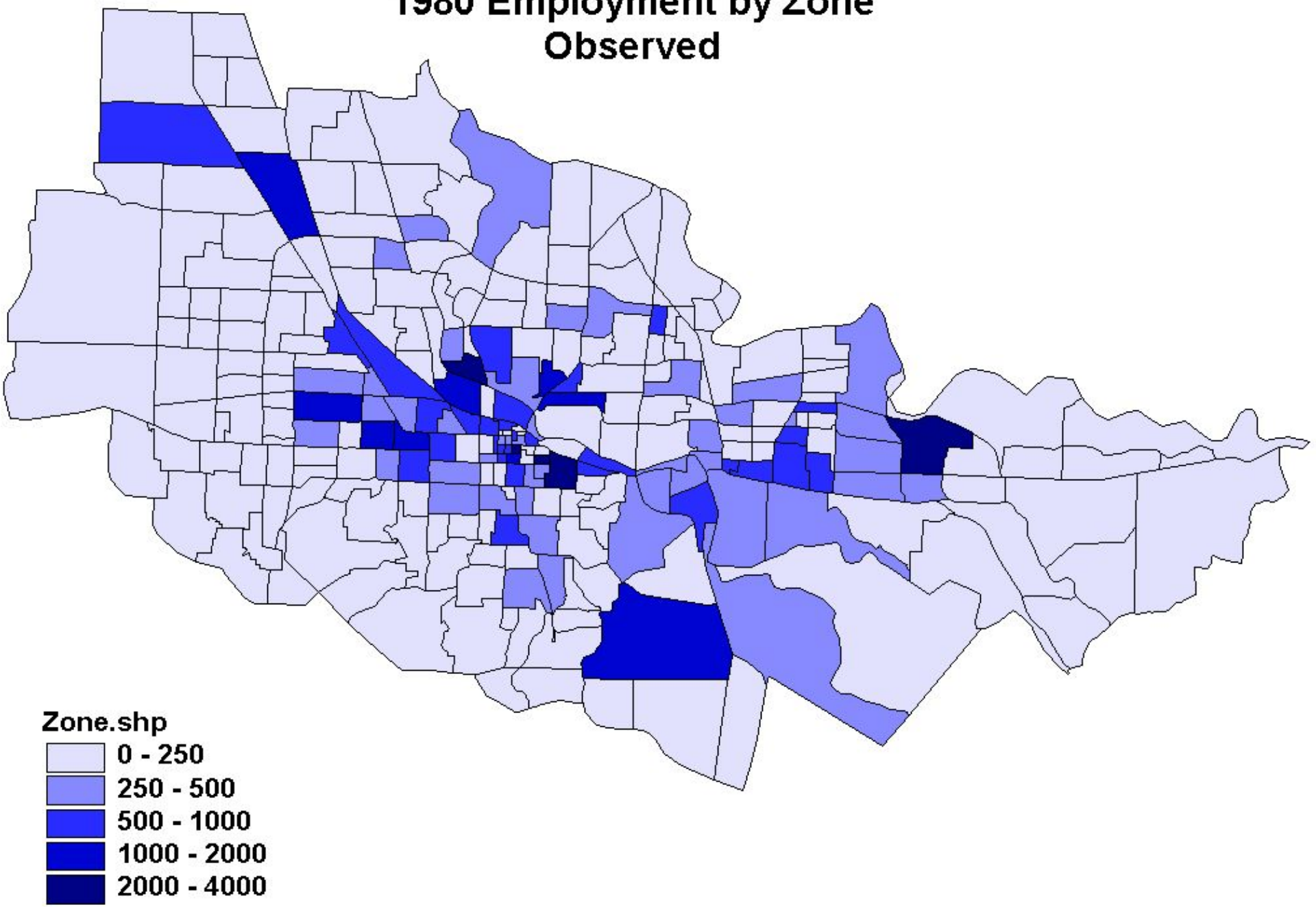
1994 Population Observed



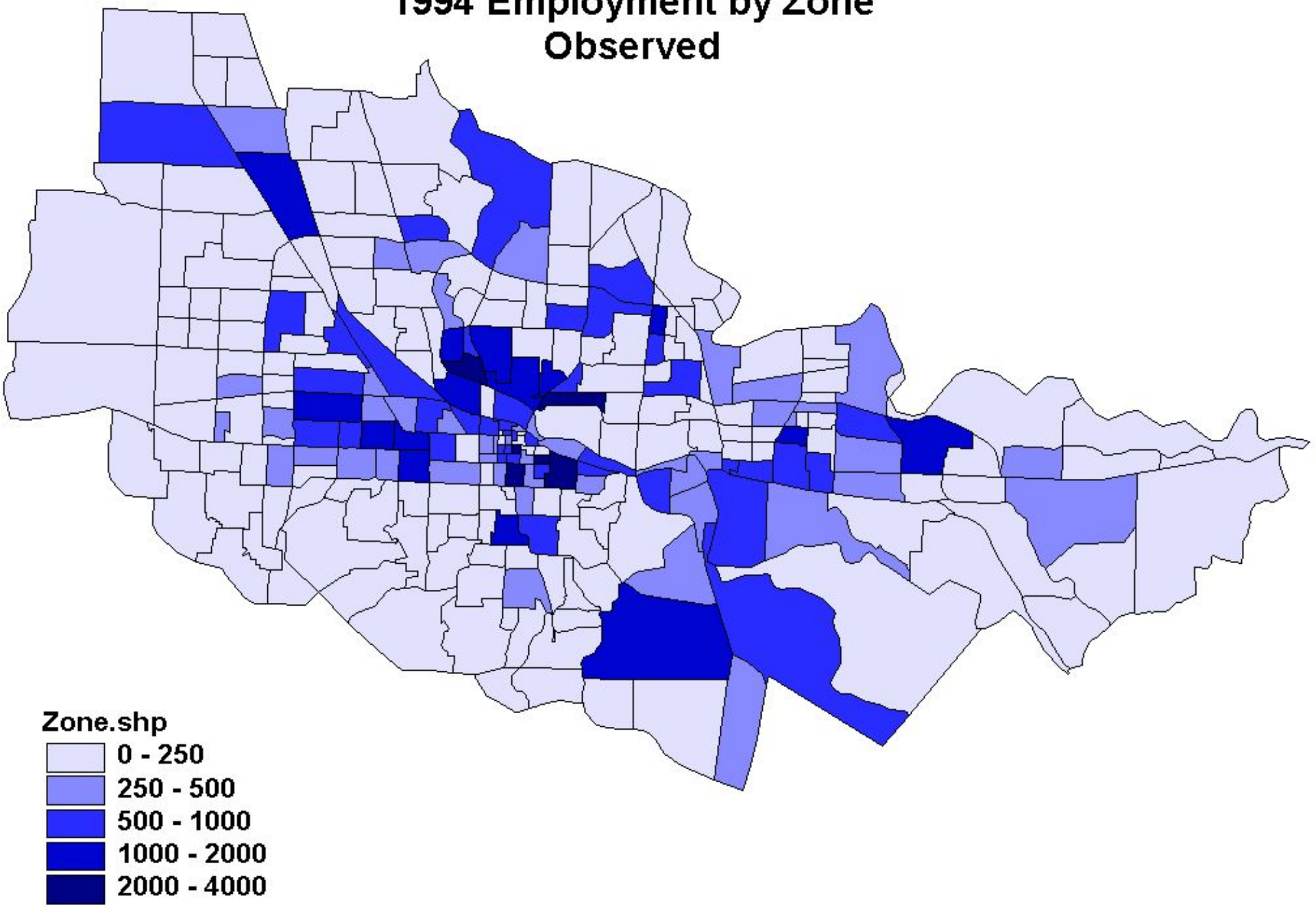
1994 Population Simulated

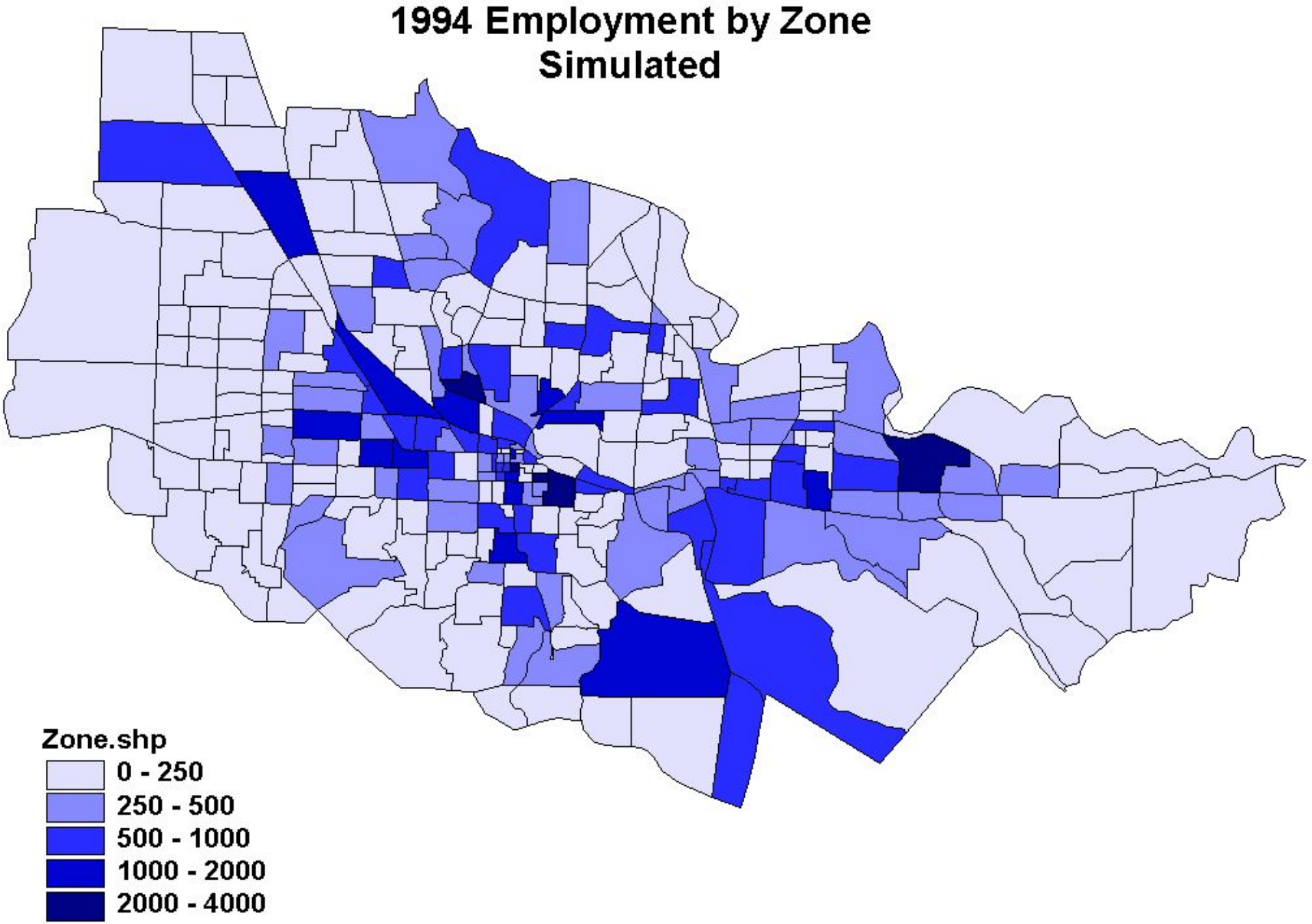


1980 Employment by Zone
Observed

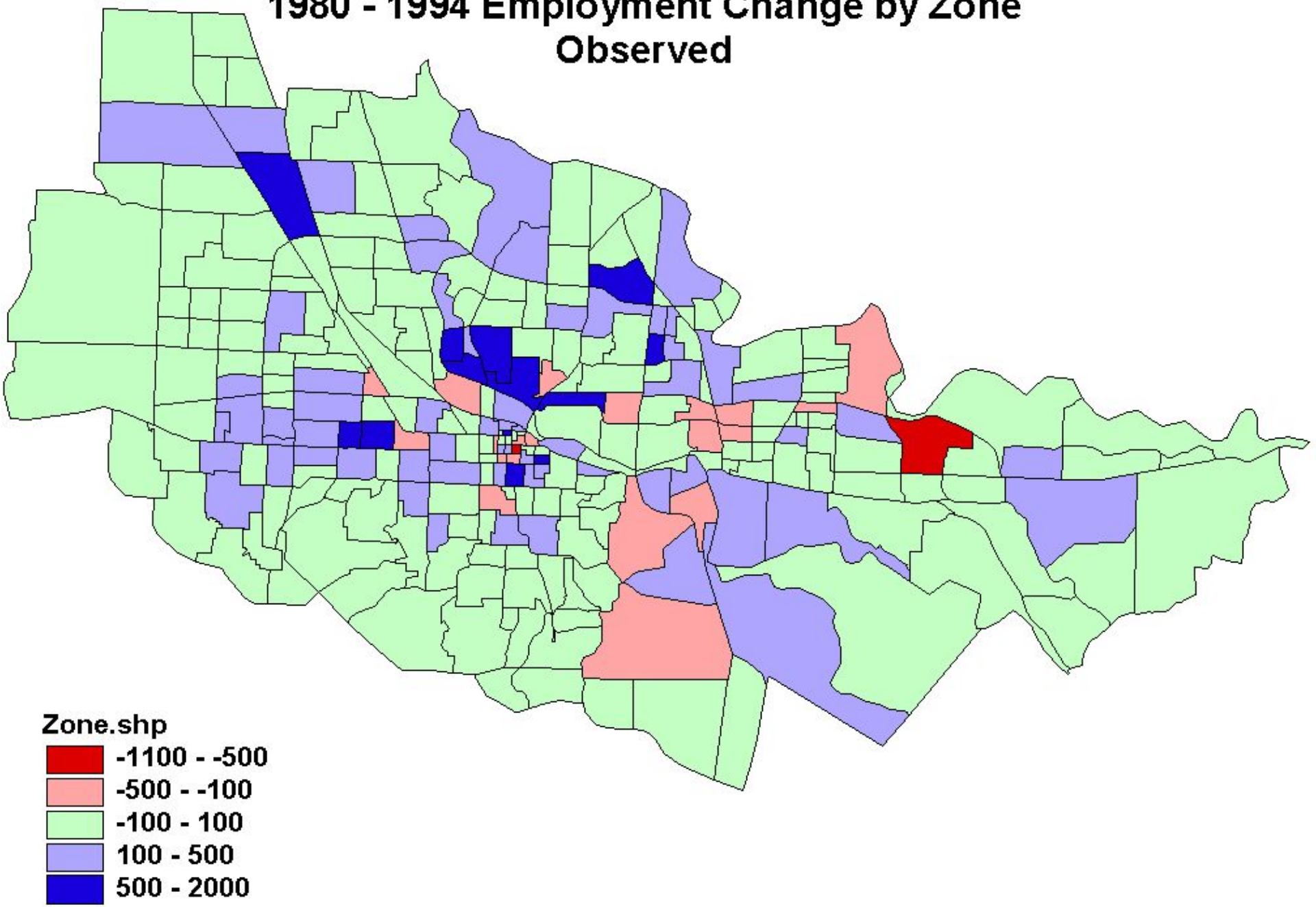


1994 Employment by Zone
Observed

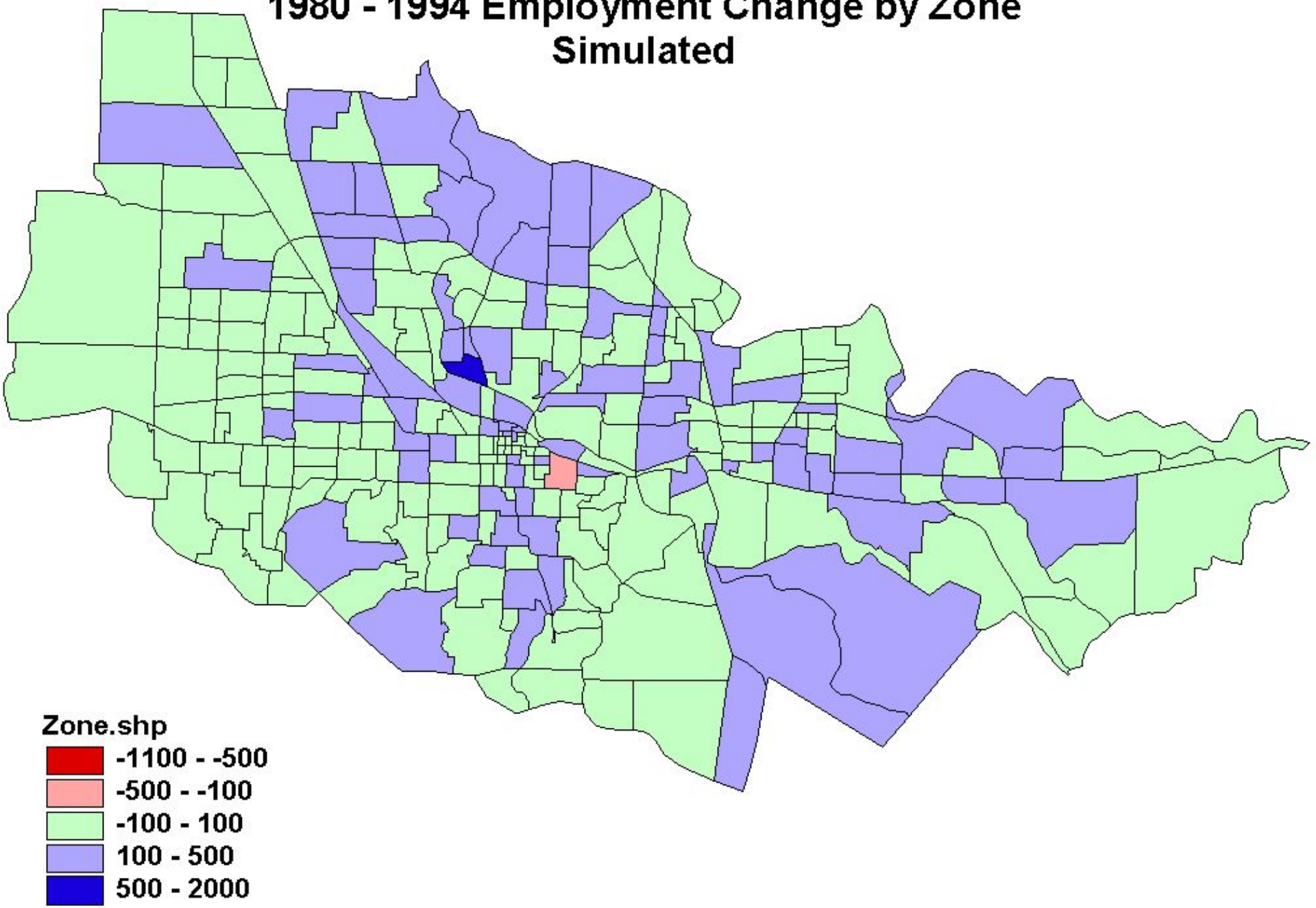



1994 Employment by Zone
Simulated
Zone.shp
0 - 250
250 - 500
500 - 1000
1000 - 2000
2000 - 4000

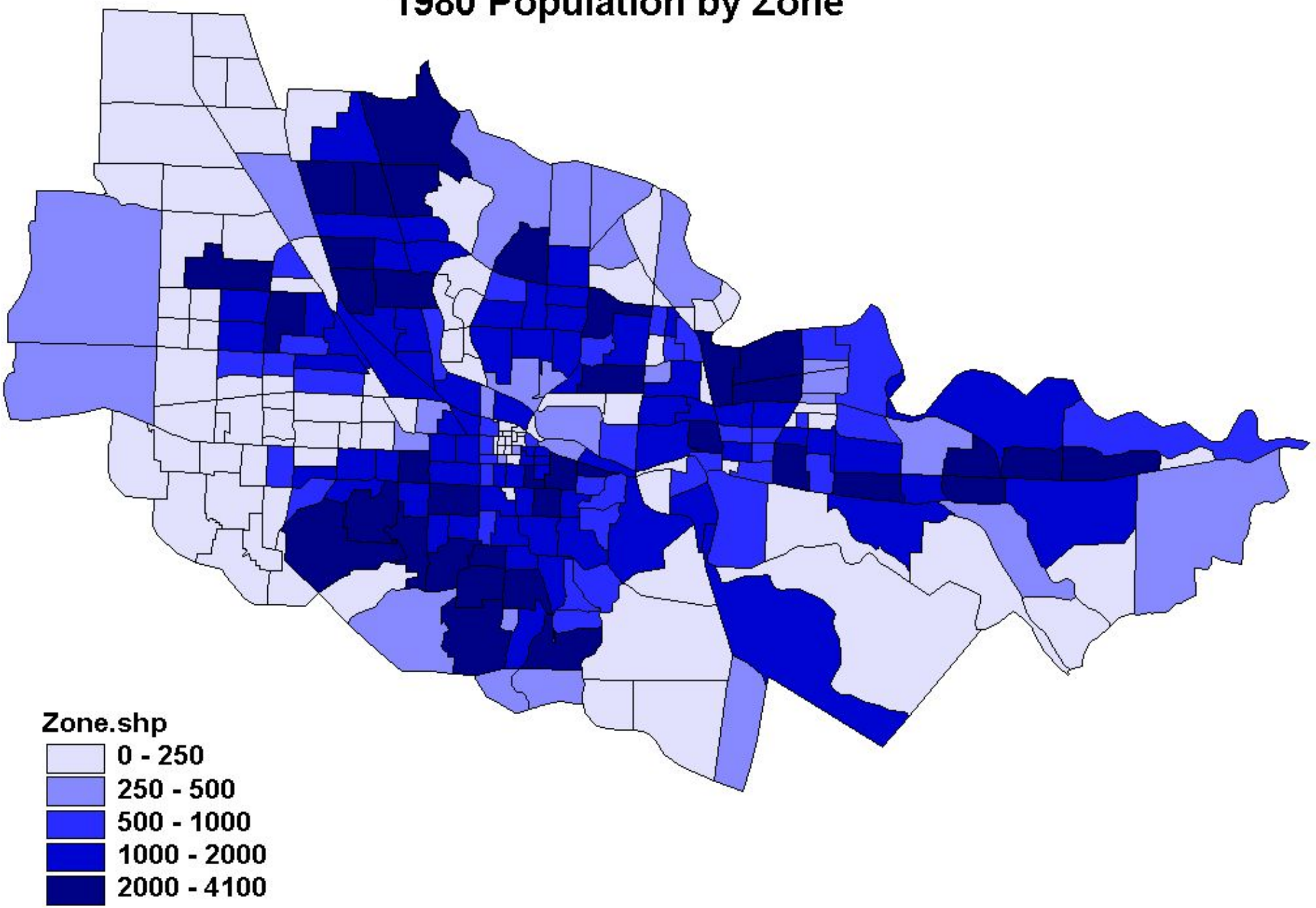
1980 - 1994 Employment Change by Zone
Observed

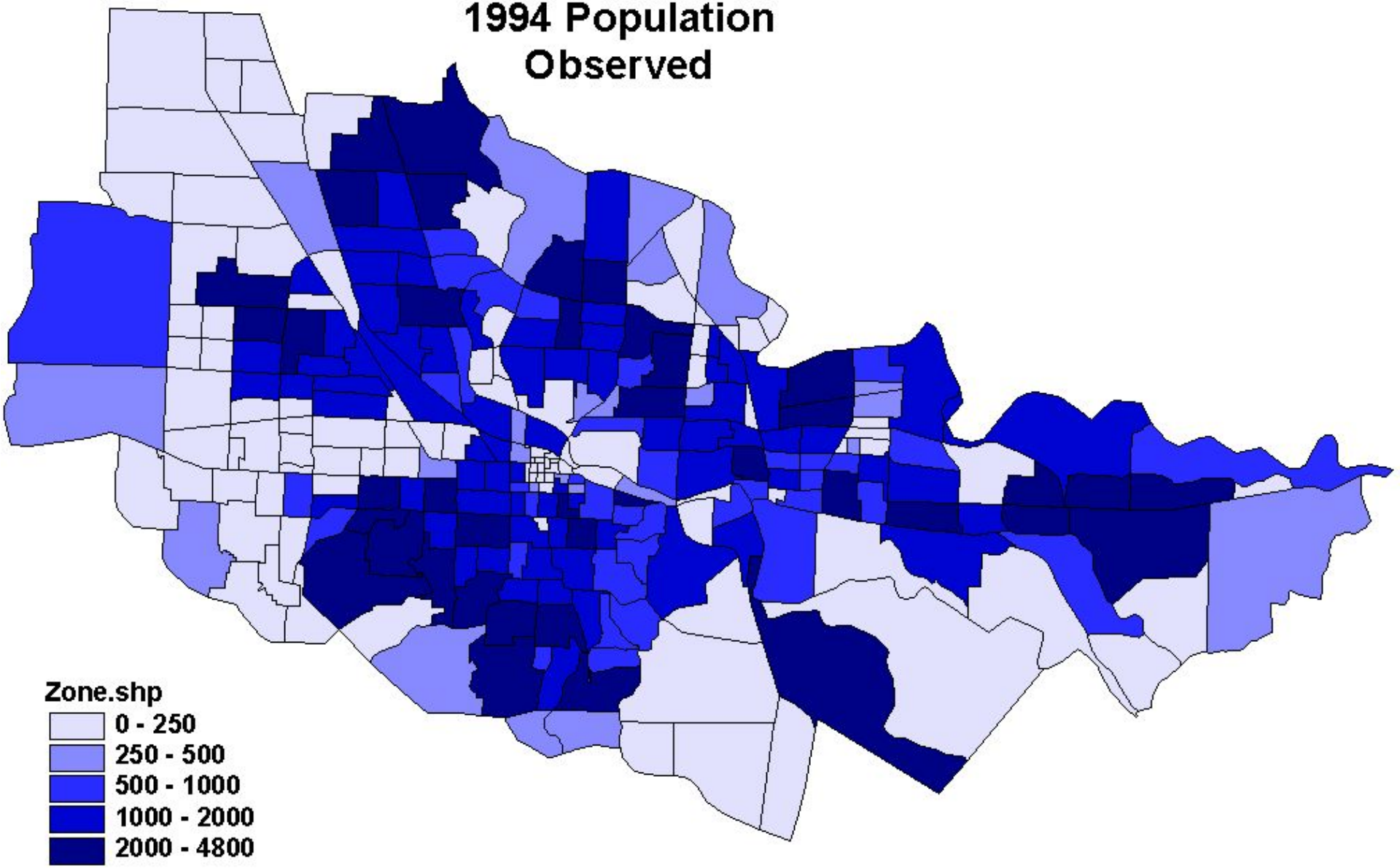


1980 - 1994 Employment Change by Zone
Simulated

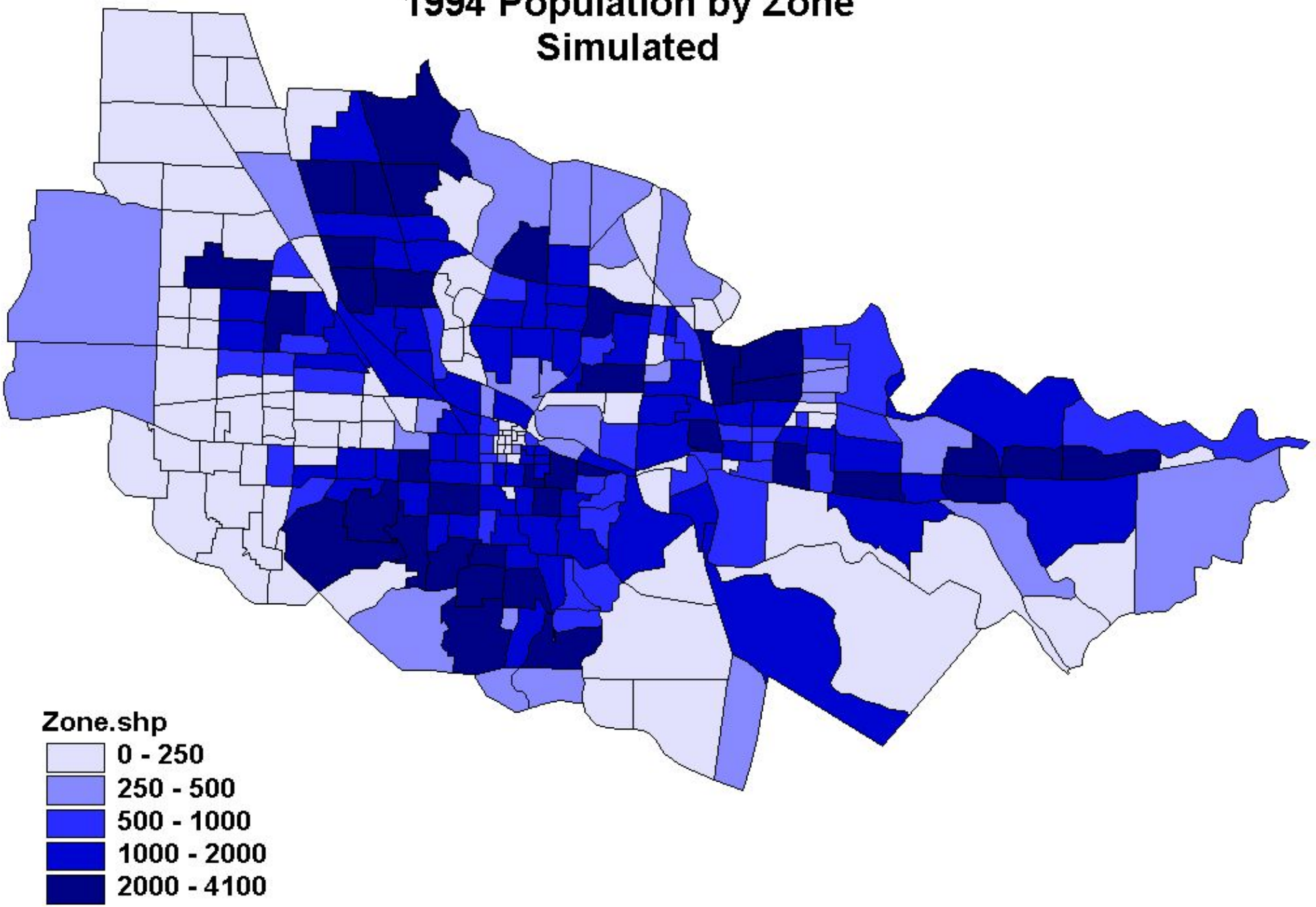


1980 Population by Zone

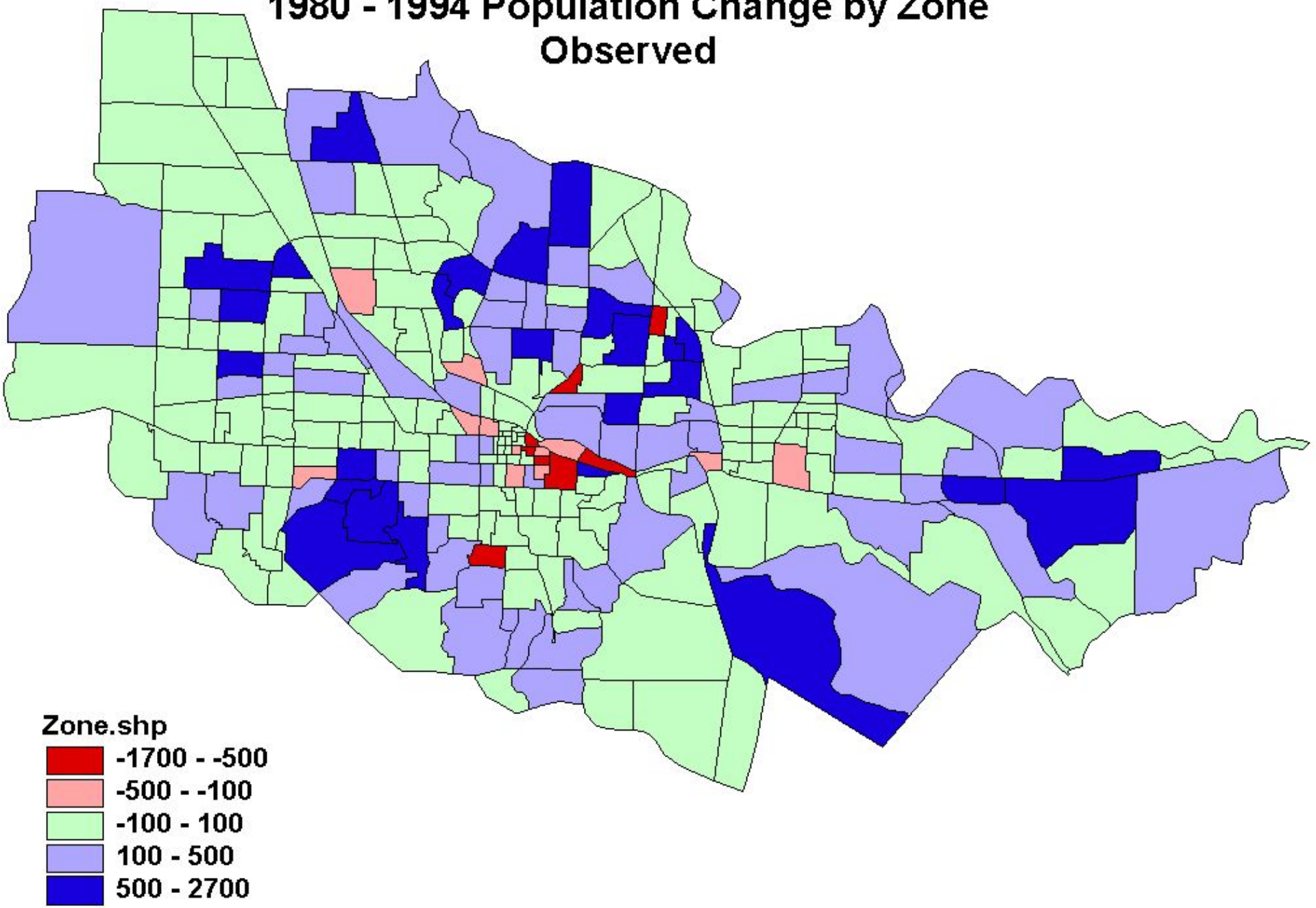



1994 Population
Observed
Zone.shp
0 - 250
250 - 500
500 - 1000
1000 - 2000
2000 - 4800

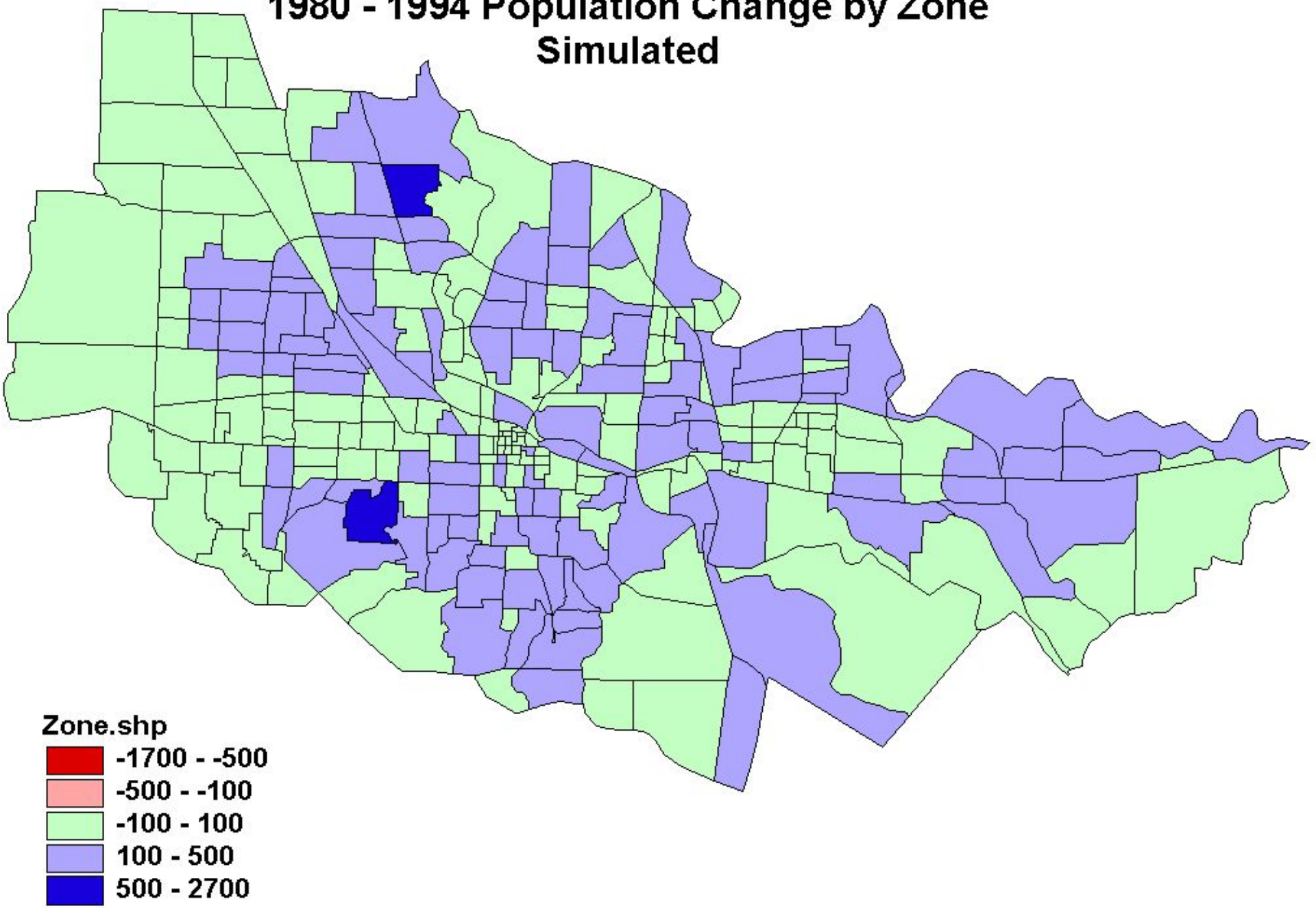
1994 Population by Zone
Simulated



1980 - 1994 Population Change by Zone
Observed



1980 - 1994 Population Change by Zone
Simulated



Goodness of Fit Measures

- R-Squared: Predicted 1994 vs Observed

- Cell Employment .64
- Cell Population .54
- Cell Land Value .45
- Cell Sqft .57
- Cell Units .52

Goodness of Fit Measures

- R-Squared: Predicted 1994 vs Observed

- Zone Employment .77
- Zone Population .84
- Zone Land Value .64
- Zone Sqft
- Zone Units .88

Goodness of Fit Measures

- R-Squared: Predicted 1994 vs Observed Cell Average with Radius of 1 cell

- Cell Employment .84
- Cell Population .81
- Cell Land Value .66
- Cell Sqft .82
- Cell Units .79

Goodness of Fit Measures

- R-Squared: Predicted 1994 vs Observed Cell Average with Radius of 2 cells

- Cell Employment .90
- Cell Population .88
- Cell Land Value .76
- Cell Sqft .89
- Cell Units .87

Goodness of Fit Measures

- R-Squared: Predicted 1994 vs Observed Cell Average with Radius of 3 cells

- Cell Employment .93
- Cell Population .91
- Cell Land Value .81
- Cell Sqft .92
- Cell Units .90

Future Work

- Short-term
  - Multiple interaction with travel models
  - Sensitivity testing
- Long-term
  - Lifestyle choices: integrate long and short-term
    - Labor market: participation, hours, job search
    - Housing market: tenure, mobility, housing search
    - Vehicle ownership
    - Daily activity and travel patterns
- Microsimulation of market interactions

Theoretical Framework: Lifestyle

- Market segmentation
  - Lifestyle: patterns of long and short-term choices
  - Segmentation using demographics, life cycle, values
  - Knowing segment improves predictive accuracy
- Lifestyle choice
  - Market segmentation begs the question
    - How do households choose a lifestyle?
    - How do choices evolve over life cycle?
    - How do choices adapt to exogenous changes?

More Information

- Release Schedule
  - Version 1.0 in next few weeks
  - Subsequent release:
    - User interface
    - Data preparation tools
    - Visualization
- Web site: http://urbansim.org