UrbanSim

Development and Calibration of the Oregon Prototype Metropolitan Land Use Model

Oregon Symposium on Integrated Land Use and Transport Models

Portland, Oregon 1998

Paul Waddell

Development Team:

Prototype Version of UrbanSim:

Urban Analytics

In Association With:

Parsons Brinckerhoff Quade and Douglas, Inc.

ECONorthwest, Inc.

KJS Associates

Beta Version of UrbanSim:

University of Washington

Sponsors:

- Oregon Department of Transportation
  - Prototype Version; 2nd Generation Model

- Oahu Metropolitan Planning Organization
  - Original Design; Link to Activity-based travel model model

- State of Utah, Governor's Office
  - Linkage to Public Participation; Infrastructure Models Models

- National Cooperative Highway Research Program Program
  - Development of Beta Version of Software
  - Documentation and Web Site: http://urbansim.org http://urbansim.org

Motivation

- Land Use-Transportation Integration
- Growth Management Strategies
- Environmental Constraints
- Interactions of Markets and Policies
- Foundation for Further Development
- User-Friendly Software
- Open the 'Black Box'

Behavioral Foundation

- Households and Businesses:
  - Move, Building Type, and Location
- Developers:
  - New Construction and Redevelopment
- Governments:
  - Land Use Plans, Infrastructure, Environmental Constraints, Growth Management Strategies

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; Nested Logit

Data Requirements

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

Zonal System

- Uses Same Zone Structure as Travel Models for Consistency

- Zones and Land Use Types Define Submarkets

- Demand Operates at Submarket Level

- Supply Operates at Parcel Level

- Market Interaction Operates at Submarket

Outputs

- Population and Households by Type
    - Income
    - Age
    - Household Size
    - Children
- Businesses by Industry and Size
    - Industry
    - Size
- Land Use and Density
- Housing Units, Commercial Square Feet, Prices by Type

Computing Requirements

- ## Computer Requirements
  - Any computing platform supporting Java 1.2
  - RAM: 64MB or more (Depends on Zones)

- ## User-Friendliness
 - Software Developed Since 1995 Using Modern Object-Oriented Software Standards
  - User-Friendly Interface
  - Results Written to ASCII for Portability

Key Features of Software

- Object-Oriented Implementation in Java
- Platform-independent
- Inter-operates with Travel Models
- Results Written to ASCII for Portability
- User Interface Exposes Land Policy Assumptions for Testing

Software Components
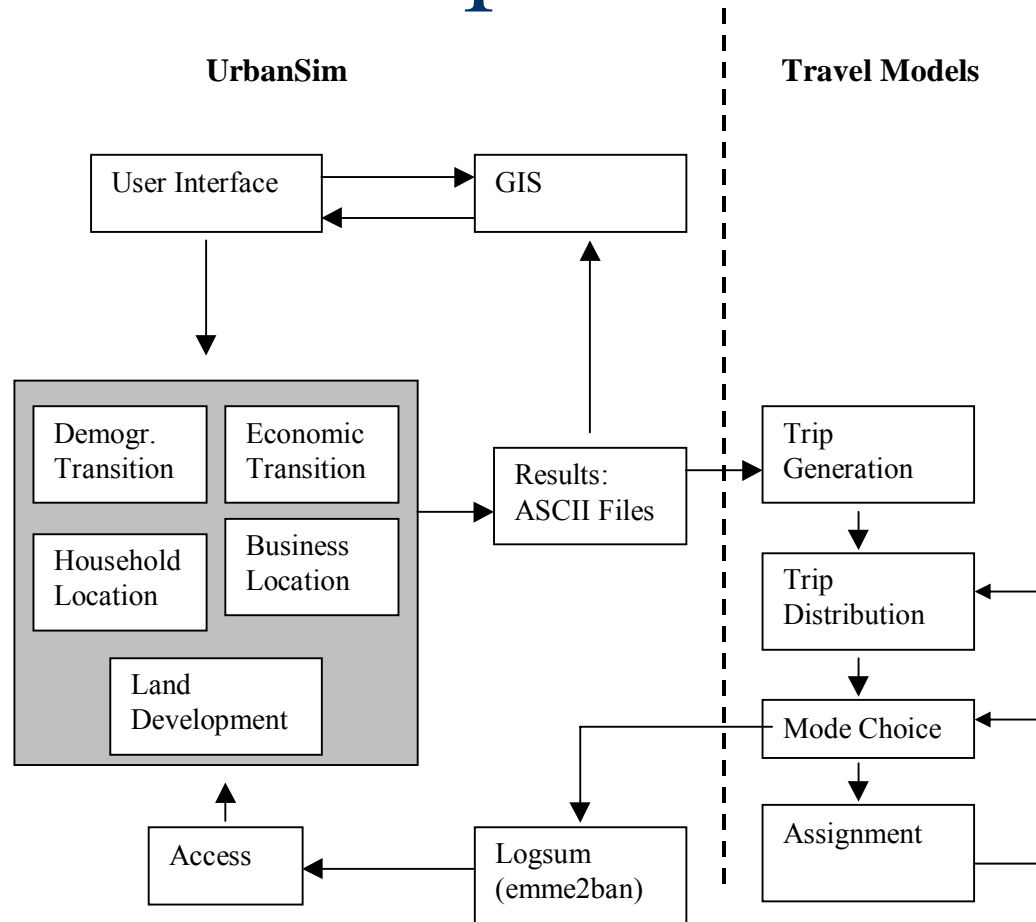
The Role of Access

- Composite Utility of Access to Activities
  - Employment by Type
  - Population by Type
- Accessibility Indices Updated Annually
  - Activity Distribution Updated Annually
  - Travel Utility Updated With Travel Model Runs
- Accessibility Enters Residential and Business Bid Functions for Locations
  - Provides the Land Use Effect of Transport

Travel Model Interface

- Supports Emme/2 in native format
- Supports all other travel models in ASCII format
- Supports Interactive Analysis With Travel Models
- Accessibility from Travel Models
  - Composite Utility from Mode Choice
  - Composite Utility from Logit-based Destination Choice

Accessibility Index for 4-Step Model

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

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

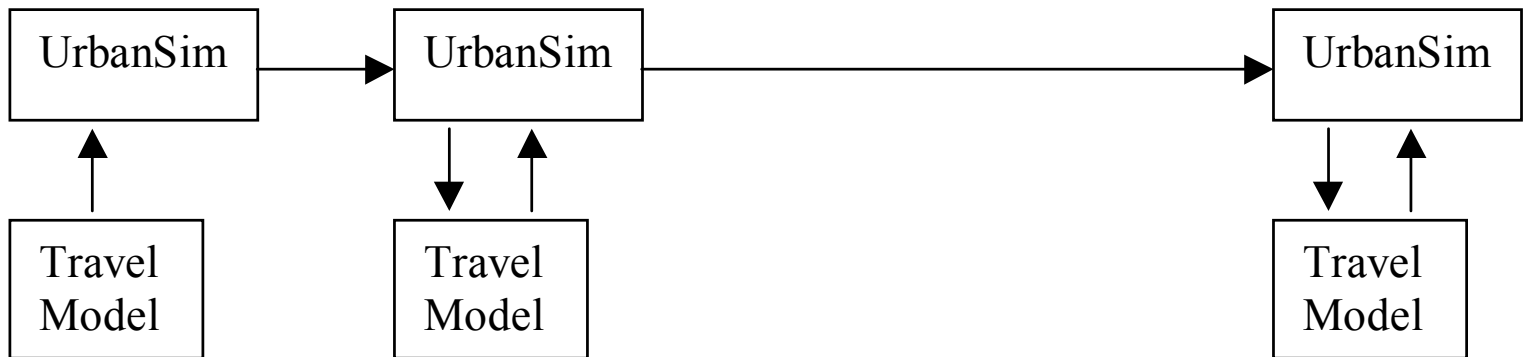# Accessibility Index for Honolulu Activity-Based Model

- Use Composite Utility (logsum) from
  - Workplace Destination Choice
  - Other Non-Work Destination Choice
- Could Generalize to Composite Utility of Travel Across All Activities
- Access Indices Enter Residential or Business Bid Functions for Locations

Interaction With Travel Models

Year:

TM1 | +1 | +2 | +3 | +4 | TM2 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | TM3

Travel Time 1 ⟶ Travel Time 2 ⟶ Travel Time 3

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┌──────────┐      ┌──────────┐                        ┌──────────┐
│ UrbanSim │─────▶│ UrbanSim │───────────────────────▶│ UrbanSim │
└──────────┘      └──────────┘                        └──────────┘
     ▲              │    ▲                               │    ▲
     │              ▼    │                               ▼    │
┌──────────┐      ┌──────────┐                        ┌──────────┐
│  Travel  │      │  Travel  │                        │  Travel  │
│  Model   │      │  Model   │                        │  Model   │
└──────────┘      └──────────┘                        └──────────┘
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(TM = Travel Model Year)

Growth Management Policies

- Land Use Plans
- Environmental Constraints
  - Slope
  - Wetlands
  - Fault Zones
- Density Constraints
- Urban Growth Boundaries
- Development Impact Fees
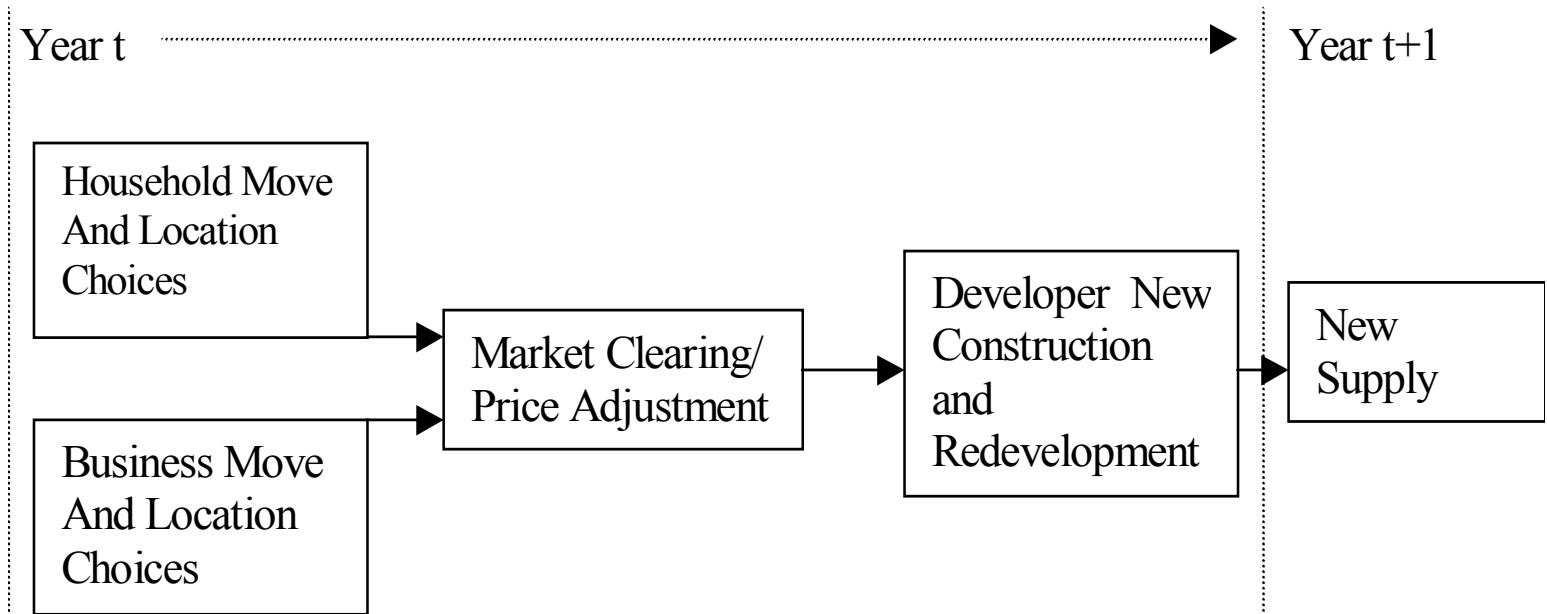- Tax Abatements

Land Market Interactions

- Model Components Linked through Land Market Interactions
- Prices Assure Consistency
- Model is Quasi-Dynamic, with Annual Steps
- Model Does Not Assume:
  - Perfect Information
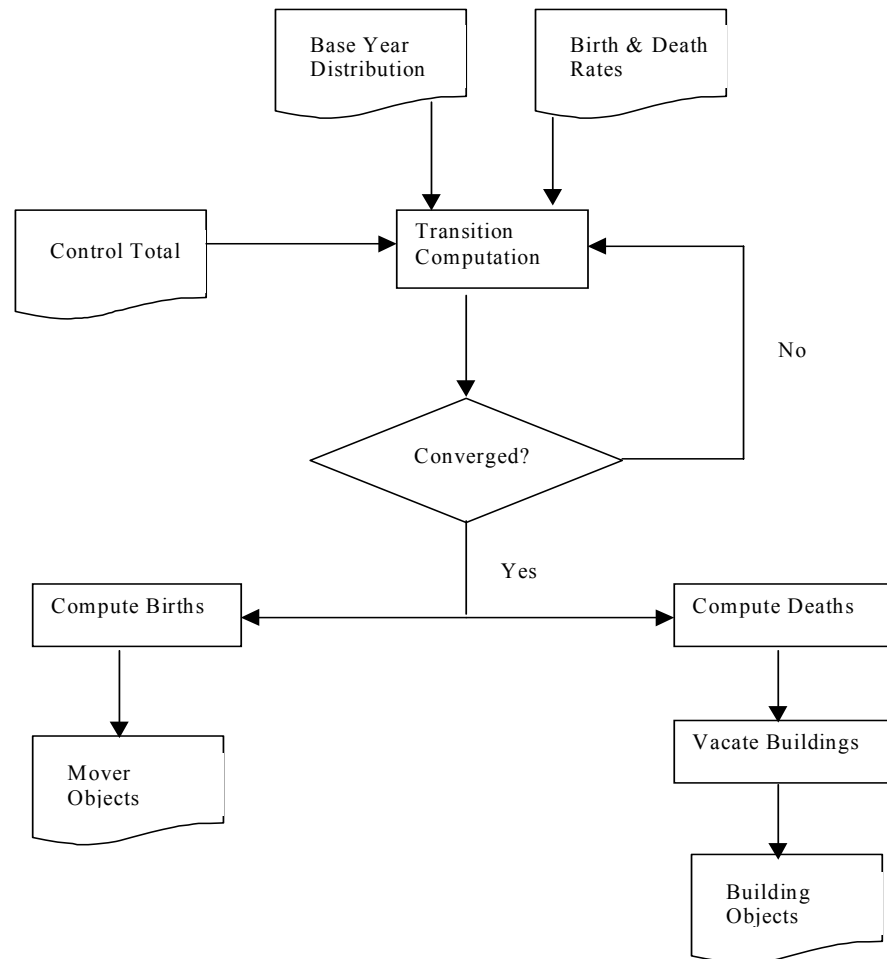 - Costless Transactions
  - Full Equilibrium

Dynamic Urban Development

- **Model Move Decisions**
  - Cross-Sectional/Equilibrium Models May be Biased; we know:
    - Moving Transaction costs are significant
    - Household Mobility Varies by Age, Inc.
    - Business Mobility Varies by Size, Sector
- **Model Incremental Land Development**
  - Existing Buildings
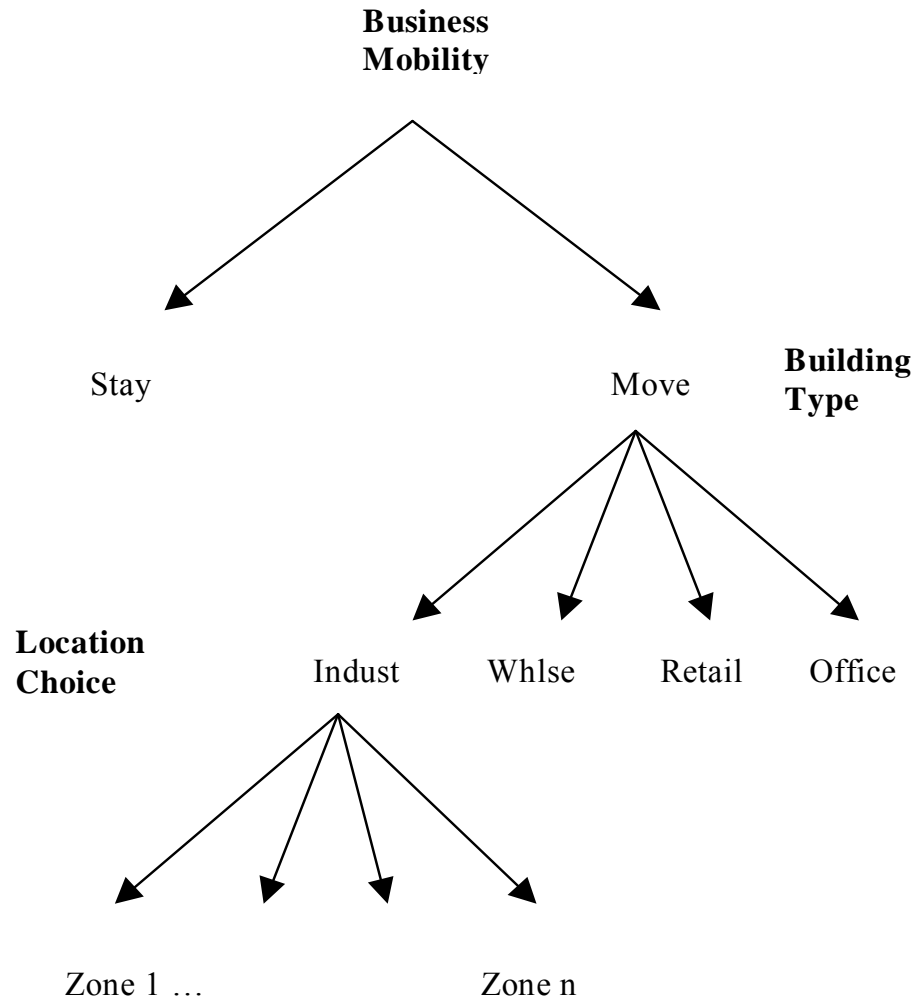 - New Construction
  - Redevelopment

Temporal Dynamics

Year t ....▶ Year t+1

```
┌─────────────────┐
│ Household Move   │
│ And Location     │
│ Choices          │──────┐
└─────────────────┘      │    ┌──────────────────┐      ┌──────────────────┐      ┌──────────┐
                         ├───▶│ Market Clearing/ │─────▶│ Developer  New   │─────▶│ New      │
┌─────────────────┐      │    │ Price Adjustment │      │ Construction     │      │ Supply   │
│ Business Move    │──────┘    └──────────────────┘      │ and              │      └──────────┘
│ And Location     │                                     │ Redevelopment    │
│ Choices          │                                     └──────────────────┘
└─────────────────┘
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Transition Model

Base Year Distribution

Birth & Death Rates

Control Total

Transition Computation

Converged?

No

Yes

Compute Births

Compute Deaths

Mover Objects

Vacate Buildings

Building Objects

Nested Location Model Structure

Business Mobility

Building Type

Location Choice

Stay

Move

Indust   Whlse   Retail   Office

Zone 1 …   Zone n

Nested Logit Structure

$$P(h) = \frac{e^{V_h + \mu V_h'}}{\sum_{h'} e^{V_h + \mu V_{h'}'}} \qquad \text{Marginal Choice of Housing Type}$$

$$V_h' = \ln \sum_l e^{V_l} \qquad \text{Logsum}$$

$$P(l|b) = \frac{e^{V_l}}{\sum_{l'} e^{V_{l'}}} \qquad \text{Conditional Choice of Location}$$

Consumer Surplus

Consumer surplus is willingness to pay (bid) less the market price for an alternative:

$$CS_{hi} = \Theta_{hi} - p_i$$

Location choice is a function of consumer surplus:

$$P_{i|h} = \frac{e^{\mu(\Theta_{hi} - p_i)}}{\sum\limits_{j} e^{\mu(\Theta_{hj} - p_j)}}$$

Household Bid Functions

Household Bid Price Variables

	Definitions
Residential 2-4	Dummy variable for housing type residential with 2-4 units (duplex, triplex or quadplex)
Multi-family	Dummy variable for housing type multi-family, with 5 or more units
lnAccEmployment	Log of accessibility to total employment, with an exponent on the logsum of 1
lnAcc4Retail	Log of accessibility to retail employment, with an exponent on the logsum of 4
Density (units/acre)	The net density in units per acre of a particular housing type in a zone
lnUnits	Log of the number of housing units of a particular type in the zone
lnAge	Log of the average age of the buildings of a type in a zone
PctIncome1	Percent of households in a zone in the lowest income group
PctIncome2	Percent of households in a zone in the second lowest income group
PctIncome4	Percent of households in a zone in the highest income group
PctChild	Percent of the households in a zone that have one or more children
PctLandIndustrial	Percent of the developed land in the zone that is in industrial use
PctLandResidential	Percent of the developed land in a zone that is in residential use
TimeToCBD	Travel time to the Central Business District, in minutes

Household Bid Results

	INCOME GROUP 1		INCOME GROUP 2		INCOME GROUP 3		INCOME GROUP 4	
	Child	No Child	Child	No Child	Child	No Child	Child	No Child
Intercept	0.8661	5.0712	0.8730	3.3327	4.9405	5.5321	7.2061	4.1270
	(0.759)	(5.170)	(0.680)	(3.227)	(7.243)	(8.915)	(3.197)	(1.163)
Residential 2-4	-0.4297	-0.4815	-0.4507	-0.5162	-0.4179	-0.5848		-0.7776
	-(15.306)	-(19.994)	-(15.398)	-(22.857)	-(9.869)	-(30.252)		-(6.979)
Multi-family	-1.0447	-1.0189	-1.1022	-1.0711	-1.1099	-1.3607	-0.9856	-1.8252
	-(27.161)	-(41.734)	-(20.692)	-(33.888)	-(9.894)	-(35.988)	-(4.170)	-(20.402)
lnAccEmployment	0.8089	0.4326	0.7912	0.6155	0.4593	0.4198	0.3329	0.6557
	(8.081)	(5.045)	(6.845)	(6.694)	(7.167)	(7.059)	(1.619)	(2.020)
lnAcc4Retail		0.0307	0.0077	0.0075	0.0347	0.0087	0.0955	0.0403
		(3.427)	(0.931)	(0.954)	(3.983)	(0.999)	(5.799)	(1.537)
Density (units/acre)	-0.0063	-0.0053	-0.0091	-0.0061	-0.0310	-0.0018	-0.0128	-0.0020
	-(5.488)	-(9.786)	-(4.530)	-(6.963)	-(7.605)	-(1.557)	-(2.700)	-(0.592)
lnUnits	-0.0016	-0.0270	-0.0056	-0.0271	-0.0011		-0.1389	-0.0351
	-(0.131)	-(2.850)	-(0.532)	-(3.104)	-(0.094)		-(6.510)	-(1.202)
lnAge	-0.0929	-0.0789	-0.0791	-0.1416	-0.1789	-0.1770	-0.3714	-0.5391
	-(3.775)	-(4.484)	-(3.229)	-(7.672)	-(7.008)	-(8.486)	-(9.261)	-(9.385)
PctIncome1	-0.0131	-0.0096	-0.0142	-0.0102	-0.0123	-0.0107	-0.0103	-0.0064
	-(12.603)	-(10.906)	-(15.290)	-(11.828)	-(12.604)	-(11.475)	-(4.937)	-(1.893)
PctIncome2	-0.0145	-0.0161	-0.0157	-0.0140	-0.0166	-0.0137	-0.0178	-0.0084
	-(12.006)	-(14.971)	-(14.684)	-(14.921)	-(14.184)	-(13.167)	-(10.116)	-(3.419)
PctIncome4	0.0045	0.0098	0.0075	0.0157	0.0030	0.0080	0.0019	0.0094
	(1.642)	(4.505)	(3.600)	(8.996)	(1.738)	(4.924)	(0.861)	(2.803)
PctChild	0.0032	0.0026	0.0059	0.0027	0.0014	-0.0020	-0.0061	-0.0144
	(3.445)	(3.211)	(7.029)	(3.376)	(1.501)	-2.0500	-(3.863)	-(5.798)
PctLandIndustrial	-0.0057	-0.0108	-0.0051	-0.0097	-0.0029	-0.0057		-0.0188
	-(6.241)	-(15.680)	-(6.077)	-(14.347)	-(2.852)	-(5.292)		-(4.819)
PctLandResidential	0.0011		0.0027		0.0053	0.0031	0.0099	0.0039
	(1.732)		(4.944)		(9.612)	(5.870)	(12.323)	(2.971)
TimeToCBD	0.0204	0.0126	0.0187	0.0129			0.0160	0.0181
	(2.642)	(2.006)	(2.552)	(2.033)			(1.377)	(0.964)
N	1352	2432	1681	2878	1413	2085	438	508
Adjusted R^2	0.76	0.79	0.73	0.73	0.69	0.74	0.76	0.73

Business Bid Functions

Business Bid Price Variables

	Definitions
IndustrialDummy	Dummy variable for industrial building type
WarehouseDummy	Dummy variable for warehouse building type
RetailDummy	Dummy variable for retail building type
LnAccessIncome4	Log of access to households in the highest income group
PctAccessIncome4	High income households as a percentage of access to all households
EmpPopAccessRatio	Ratio of employment access to population access
lnAccessEmployment	Log of access to total employment
lnAccPop+Emp	Log of access to total employment and population
BasicGrossDensity	Basic employment in a zone per square mile
RetailGrossDensity	Retail employment in a zone per square mile
ServiceGrossDensity	Service employment in a zone per square mile
PctAccRetail	Retail employment as a percentage of access to total employment
PctAccService	Service employment as a percentage of access to total employment
lnSQFT	Log of the total square feet of commercial space of a particular type
lnAge	Log of building age
Density (Floor/Area)	Net density of the building type in a zone
PctIndustrialLand	Percent of developed land in a zone in industrial use
PctRetailLand	Percent of developed land in a zone in retail use
CBDTime	Travel time to the CBD, in minutes
HWY	Dummy variable for presence of a highway in a zone

Business Bid Results

	SERVICE	RETAIL	BASIC
INTERCEPT	0.5826	-0.7054	-2.6015
	(0.317)	-(0.437)	-(0.681)
IndustrialDummy	-0.5763	0.1113	-0.0099
	-(3.518)	(0.584)	-(0.114)
WarehouseDummy	-0.8486	-0.6661	-0.5980
	-(8.701)	-(5.299)	-(8.117)
RetailDummy	-0.5156	-0.1912	-0.4726
	-(12.757)	-(4.013)	-(6.879)
LnAccessIncome4	0.4026		
	(2.139)		
EmpPopAccessRatio	2.0151		
	(6.116)		
PctAccessIncome4		0.3458	
		(3.964)	
lnAccessEmployment			0.4188
			(1.370)
lnAccPop+Emp		0.1414	
		(1.126)	
BasicGrossDensity			1.02E-04
			(6.782)
RetailGrossDensity		4.75E-05	6.48E-05
		(4.850)	(3.486)
ServiceGrossDensity	3.694E-06		
	(2.950)		
PctAccRetail	0.0526	0.0464	0.0723
	(4.788)	(3.933)	(3.638)
PctAccService	-0.0451		
	-(4.628)		
lnSQFT	-0.2930	-0.1563	-0.1906
	-(18.855)	-(9.245)	-(8.019)
lnAge		-0.1203	
		-(3.469)	
Density (Floor/Area)	-0.1558	-0.3690	-0.6631
	(4.225)	-(6.485)	-(5.448)
PctIndustrialLand	-0.0035	-0.0025	-0.0062
	-(2.504)	-(2.607)	-(5.386)
PctRetailLand	0.0084		
	(8.305)		
CBDTime	0.0883		0.0466
	(4.913)		(1.593)
HWY		0.0571	
		(1.268)	
N	1056	603	458
Adj. R^2	0.50	0.42	0.50

Household Location Choice Results

Variable	Coefficient	Z (b/s.e)
Consumer Surplus	4.73E-05	6.748
LnSize	2.30E-02	4.156

Business Location Choice Results

Variable	Coefficient	Z (b/s.e)
Consumer Surplus	3.18E-02	1.768
LnSize	1.60E-02	1.479

Market Price Adjustment
in Prototype Version

$$P_{lbt} = P_{lbt-1}\left[\frac{D_{lbt}}{(1-\alpha)S_{lbt}}\right]^{\beta}$$

P_{lbt} is the land price of building type b in location l in year t

P_{lbt-1} is the previous year closing land price for the same building and location

D_{lbt} is the total demand in the current year for space in the bldg type and location

S_{lbt} is the current year total supply of space of building type b in location l

α is the normal vacancy rate

β is a scaling parameter for the price adjustment, initially set to 1

Latent Demand

$$D_{lbt} = \sum_i P(lb)_{it} M_{it} R_{lb} + \sum_i T_{ilbt} - (AV_{lbt} + TV_{lbt})$$

$P(lb)_t$ is the prob. that a mover of type i will choose bldg type b in loc. l in year t

M_{it} is the total number of movers of type i in year t

R_{lb} is the utilization rate for bldg type b (for res=1, for nonres=sqft/emp for b)

T_{ilbt} is the total quantity of occupied space in building type b, location l in year t

AV_{lbt} is the total actual vacancy (from prev year) in bldg type b, loc l, and year t

TV_{lbt} is the tentative vacancy (movers subtracted) in bldg type b, loc l, and year t

Market Price Adjustment

in Beta Version

$$P_{lbt} = P_{lbt-1} \left[\frac{\left(1 + \alpha_b - V_{lbt}\right) \left(1 + \alpha_b - V_{bt}\right)^{\lambda}}{1 + \lambda} \right]^{\beta}$$

P_{lbt} is the land price of building type b in location l in year t

P_{lbt-1} is the previous year closing land price for the same building and location

α_b is the Normal, or threshold vacancy rate for building type b

V_{lbt} is the current vacancy rate for building type b in location l

V_{bt} is the current vacancy rate for building type b across the region

λ is a regional weighting parameter

β is a scaling parameter for the price adjustment, initially set to 1

Aggregate Demand
in Prototype Version

$$D_{bt} = D_{bt-1} + \sum_{i}^{I} b_{it} - C_{it-1} \left[\frac{D_{ibt-1} - D_{ibt-2}}{\sum_{b} (D_{ibt-1} - D_{ibt-2})} \right]$$

where

D_{bt} is the aggregate demand for building type b in year t

D_{bt-1} is the aggregate demand for building type b in t-1

D_{ibt-1} is the demand for building type b in t-1 by Consumers i

D_{ibt-2} is the demand for building type b in t-2 by Consumers i

C_{it} is the Number of Consumers of type i in time t

C_{it-1} is the Number of Consumers of type i in time t-1

Aggregate Demand
in Beta Version

$$D_{bt} = D_{bt-1} + \left[(\alpha_b - V_{bt-1})S_{bt-1}\right]^{\beta}$$

where

D_{bt} is the aggregate demand for building type b in year t

D_{bt-1} is the aggregate demand for building type b in t-1

α_b is the normal market vacancy rate for building type b

V_{bt-1} is the actual vacancy rate in t-1 for building type b

S_{bt-1} is the total supply of space in building type b in t-1

β is a scaling parameter

Developer Profit

$$\hat{\Pi}_i(lb) = \hat{R}_{lb}Q_{ib} - L_iA_i - H_bQ_{ib} - S_{lb}Q_{ib} - I_{ib'}Q_{ib'} - D_{ib'}Q_{ib'}$$

$\hat{\Pi}_i(lb)$ is the expected profit from developing parcel i in loc l into bldg type b

$\hat{R}_{lb}Q_{ib}$ is the expected revenue from selling the project to household or business

L_iA_i is the land cost of parcel i (land cost per acre times acres)

H_bQ_{ib} is the 'hard' construction cost of the development project (replacement cost)

$S_{lb}Q_{ib}$ is the 'soft' construction cost of developing the project (development fees)

$I_{ib'}Q_{ib'}$ is the cost of existing improvements on parcel i if it is being redeveloped

$D_{ib'}Q_{ib'}$ is the demolition cost for any improvements on parcel i (if redeveloped)

Density

$$\Phi_{lb} = \alpha_b + \beta_b \ln(P_{lb})$$

Φ_{ib} is the density for parcels in location l and building type b

P_{lb} is the land price per acre in location l for building type b

UrbanSim beta User Interface: Open Project

UrbanSim beta Main Menu

File	Help

Scenario Editor | Coefficient Editor | Reporting

Enter Scenario or Press Browse

Browse for Scenario

Edit Scenario

Run Scenario

Model Beta 1.0, UI - Alpha 0.9
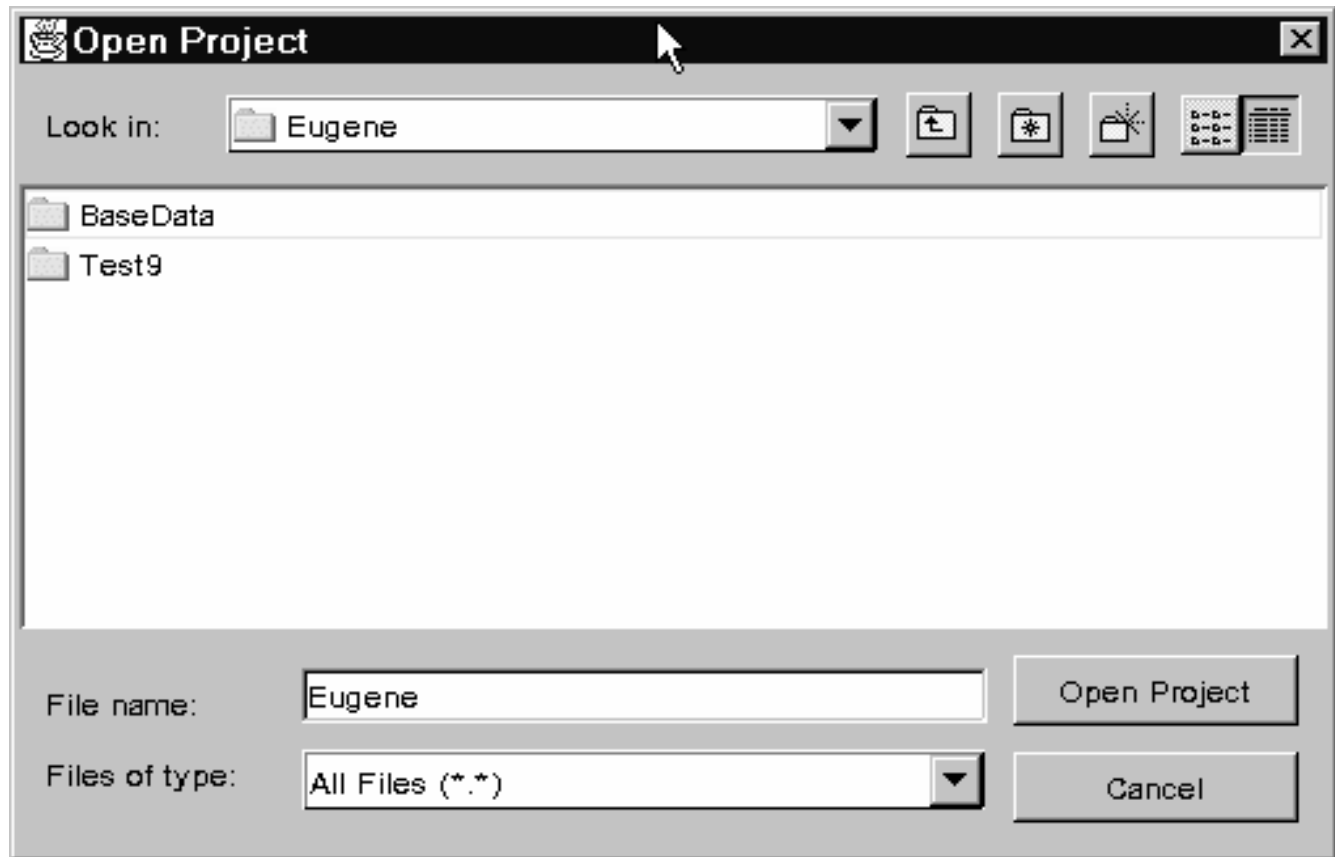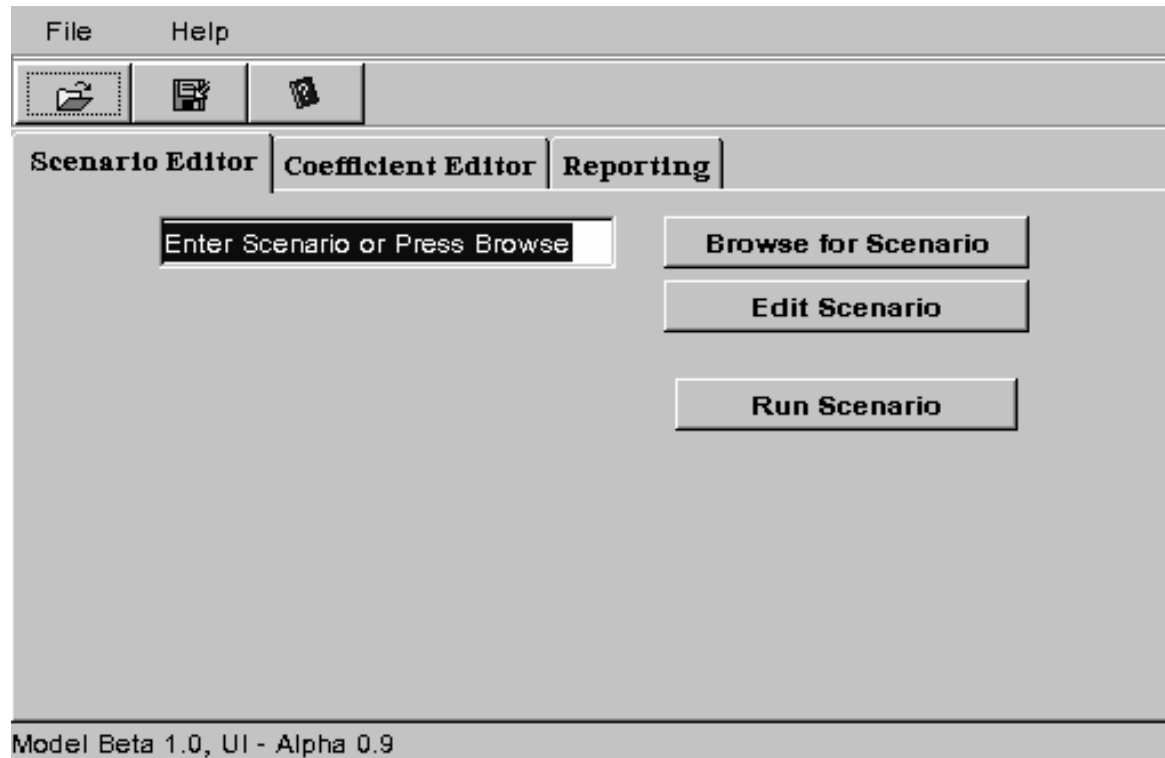
Scenario Editor

| Control Totals | Land Use Conversion | Density Constraints | Development Costs | Vacancy Rates |

Project Base Year is: 1995   Ending Year for Scenario: 2010

Year	Population	Employment	ReportYear	Travel
1995	172559	96217	☑	☐
1996	175148	97660	☑	☐
1997	177775	99125	☑	☐
1998	180441	100612	☑	☐
1999	183148	102121	☑	☐
2000	185895	103653	☑	☐
2001	188684	105208	☑	☐
2002	191514	106786	☑	☐
2003	194387	108388	☑	☐
2004	197302	110013	☑	☐
2005	200262	111664	☑	☐
2006	203266	113339	☑	☐
2007	206315	115039	☑	☐
2008	209410	116764	☑	☐
2009	212551	118516	☑	☐
2010	215739	120293	☑	☐

Land Use Conversion Rules

| Control Totals | Land Use Conversion | Density Constraints | Development Costs | Vacancy Rates |

Planned to Actual Land Use Conversion

County	City	Overlay	PLU	ALU
-1	-1	-1	1	0
-1	-1	-1	2	3
-1	-1	-1	2	6
-1	-1	-1	2	7
-1	-1	-1	3	2
-1	-1	-1	3	3
-1	-1	-1	3	6
-1	-1	-1	3	7
-1	-1	-1	3	8
-1	-1	-1	4	6
-1	-1	-1	4	7
-1	-1	-1	5	8
-1	-1	-1	6	0
-1	-1	-1	7	4
-1	-1	-1	7	8
-1	-1	-1	8	3
-1	-1	-1	9	5
-1	-1	-1	10	4
-1	-1	-1	11	2

Density Constraints

Constraints - Land Use Density

County	City	Overlay	ALU	Min Density	Max Density
-1	-1	-1	1	2.0	8.0
-1	-1	-1	2	10.0	15.0
-1	-1	-1	3	15.0	30.0
-1	-1	-1	4	0.1	1.3
-1	-1	-1	5	0.2	1.3
-1	-1	-1	6	0.25	6.0
-1	-1	-1	7	0.3	6.0
-1	-1	-1	8	0.05	4.0
-1	-1	-1	9	0.0	0.0
-1	-1	-1	10	0.0	0.0
-1	-1	-1	11	0.0	0.0
-1	-1	-1	12	0.0	0.0
-1	-1	-1	13	0.0	0.0
-1	-1	-1	14	0.0	0.0

Development Costs

| Control Totals | Land Use Conversion | Density Constraints | Development Costs | Vacancy Rates |

Hard Costs of Development

ALU	Hard Cost	Demolitio...
1	74000.0	4000.0
2	40000.0	4000.0
3	24000.0	4000.0
4	56.0	4.0
5	20.0	4.0
6	27.0	4.0
7	41.0	4.0
8	46.0	4.0
9	0.0	0.0
10	0.0	0.0
11	0.0	0.0
12	0.0	0.0
13	0.0	0.0
14	0.0	0.0

Soft Costs of Development

County	City	Overlay	ALU	SoftCost
1	1	1	1	2000.0
1	1	1	2	2000.0
1	1	1	3	2000.0
1	1	1	4	3.0
1	1	1	5	3.0
1	1	1	6	3.0
1	1	1	7	3.0
1	1	2	1	2000.0
1	1	2	2	2000.0
1	1	2	3	2000.0
1	1	2	4	3.0
1	1	2	5	3.0
1	1	2	6	3.0
1	1	2	7	3.0
1	1	3	1	2000.0
1	1	3	2	2000.0
1	1	3	3	2000.0
1	1	3	4	3.0
1	1	3	5	3.0

Vacancy Rates

Control Totals	Land Use Conversion	Density Constraints	Development Costs	Vacancy Rates

Normal Vacancy Rates

ALU	Rate
1	30.0
2	20.0
3	20.0
4	20.0
5	20.0
6	20.0
7	20.0
8	20.0
9	0.0
10	0.0
11	0.0
12	0.0
13	0.0
14	0.0

Console With Run Diagnostics

Merge Results Tool

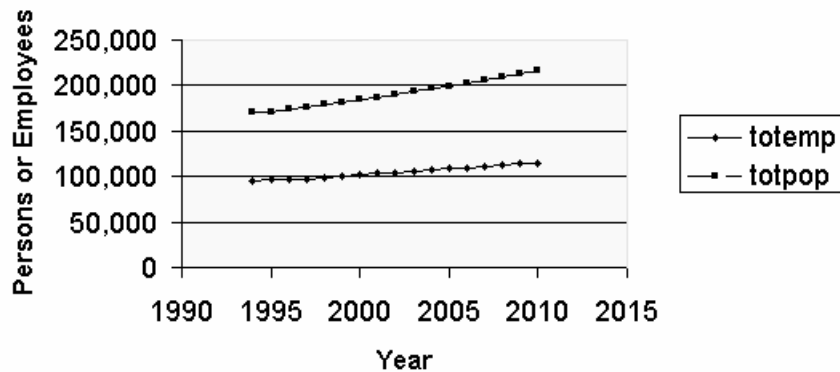|	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**Year**	totemp	totpop													
2	1994	94,795	170,009													
3	1995	96,783	171,226													
4	1996	97,535	173,455													
5	1997	97,290	176,135													
6	1998	98,348	178,818													
7	1999	100,152	181,603													
8	2000	101,497	184,469													
9	2001	103,127	187,346													
10	2002	104,032	190,622													
11	2003	105,595	193,459													
12	2004	107,151	196,369													
13	2005	108,580	199,530													
14	2006	109,869	202,696													
15	2007	110,866	205,676													
16	2008	112,780	209,294													
17	2009	113,779	212,729													
18	2010	115,025	216,181													

Total Population and Employment

Persons or Employees

250,000
200,000
150,000
100,000
50,000
0

1990 1995 2000 2005 2010 2015

Year

→ totemp
-■- totpop

Tot Pop & Emp / Res Acres / Residential Units / RES Density / NON-Res Acres

Draw ▾   AutoShapes ▾

Ready

Arial   10   E14   =

	Year	mfacres	r24acres	sfacres
1994	893	850	72,839
1995	893	850	72,839
1996	893	850	73,792
1997	893	917	73,792
1998	964	931	73,792
1999	1,001	965	73,792
2000	1,040	983	73,792
2001	1,070	1,014	73,792
2002	1,102	1,047	73,792
2003	1,140	1,064	73,792
2004	1,175	1,085	73,792
2005	1,175	1,103	73,860
2006	1,175	1,123	74,011
2007	1,175	1,147	74,293
2008	1,175	1,160	74,628
2009	1,175	1,183	74,970
2010	1,175	1,207	75,311

Residential Acres

Acres (80,000 / 60,000 / 40,000 / 20,000 / 0) vs Year (1990, 1995, 2000, 2005, 2010, 2015)

Legend: mfacres, r24acres, sfacres

Tot Pop & Emp / Res Acres / Residential Units / RES Density / NON-Res Acres

Draw   AutoShapes

Ready

	Year	mfunits	r24units	sfunits
1994	17,187	8,789	60,530
1995	17,187	8,789	60,530
1996	17,187	8,789	63,718
1997	17,187	9,558	63,718
1998	18,248	9,728	63,718
1999	18,801	10,146	63,718
2000	19,389	10,398	63,718
2001	19,845	10,835	63,718
2002	20,322	11,214	63,718
2003	20,898	11,461	63,718
2004	21,426	11,739	63,718
2005	21,426	11,950	63,960
2006	21,426	12,171	64,437
2007	21,426	12,466	65,297
2008	21,426	12,631	66,394
2009	21,426	12,915	67,595
2010	21,426	13,196	68,932
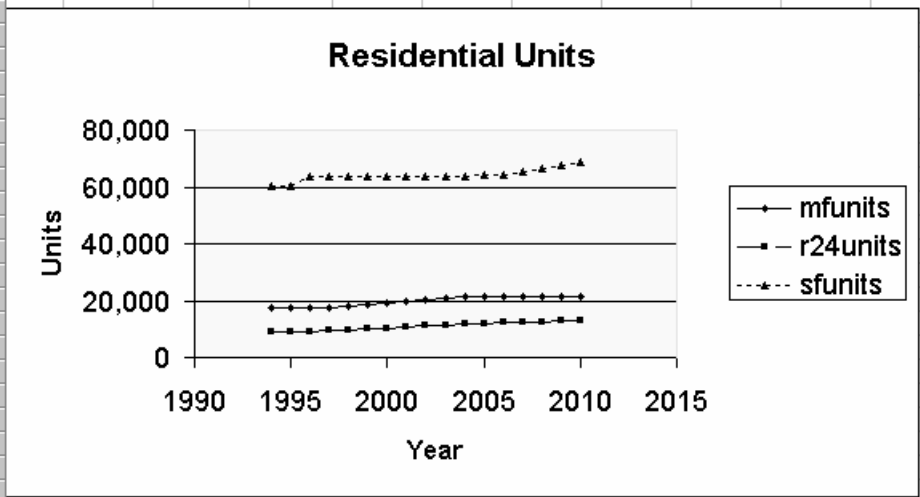
Residential Units

Tot Pop & Emp / Res Acres / Residential Units / RES Density / NON-Res Acres

Draw AutoShapes

Ready

Arial   12   **B** *I* U $ % ,   70%   Prompt

A1   =   Year

	A	B	C	D	E
1	Year	SF Density	R24 Density	MF Density	RES Density
2	1994	0.831015309	10.33404273	19.24700718	1.15987663
3	1995	0.831015309	10.33404273	19.24700718	1.15987663
4	1996	0.863481838	10.33404273	19.24700718	1.187443239
5	1997	0.863481838	10.42175506	19.24700718	1.196568399
6	1998	0.863481838	10.45043884	18.93535333	1.211497267
7	1999	0.863481838	10.50995991	18.79010174	1.223172926
8	2000	0.863481838	10.57309038	18.64667584	1.233328044
9	2001	0.863481838	10.68098026	18.54742233	1.244103562
10	2002	0.863481838	10.70855615	18.44888473	1.254321301
11	2003	0.863481838	10.77262901	18.33559991	1.264244412
12	2004	0.863481838	10.81696215	18.2356696	1.273902519
13	2005	0.865963335	10.83163381	18.2356696	1.278413158
14	2006	0.87064438	10.84247192	18.2356696	1.284711547
15	2007	0.878917081	10.86967895	18.2356696	1.294652687
16	2008	0.889671442	10.89170382	18.2356696	1.305199345
17	2009	0.901632128	10.91328522	18.2356696	1.318229355
18	2010	0.915293401	10.93280089	18.2356696	1.332855729

Residential Densities

Units per Acre (y-axis: 0, 5, 10, 15, 20, 25)
Year (x-axis: 1990, 1995, 2000, 2005, 2010, 2015)

Legend:
- SF Density
- R24 Density
- MF Density
- RES Density

Tot Pop & Emp / Res Acres / Residential Units \ RES Density / NON-Res Acres

Draw AutoShapes

Ready
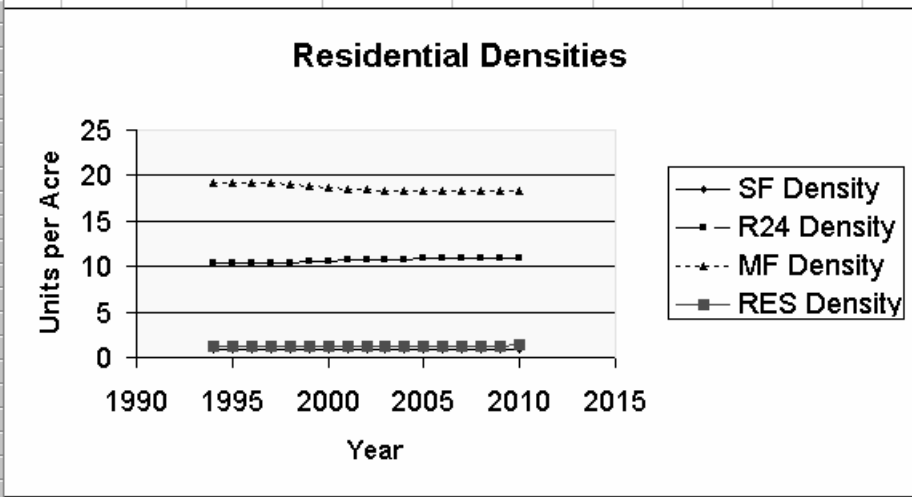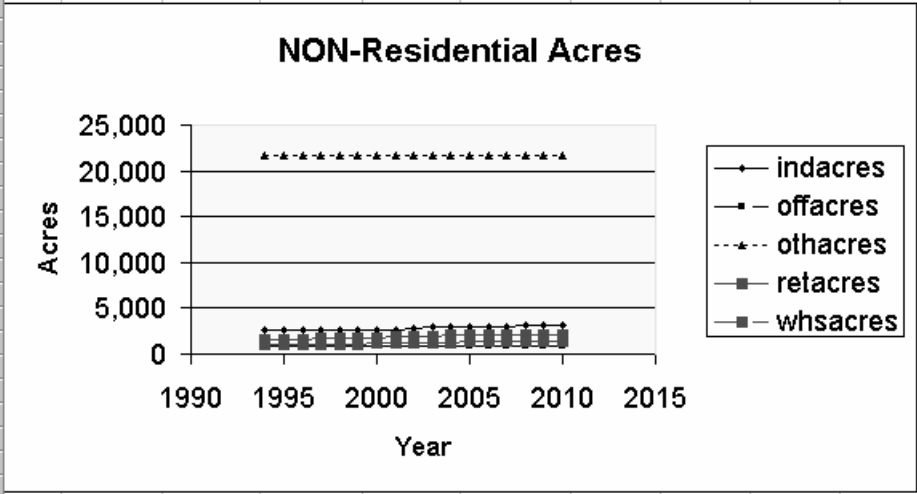
File Edit View Insert Format Tools Data Window Help

Arial   12

G1   =

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Year	indacres	offacres	othacres	retacres	whsacres									
2	1994	2,635	793	21,737	1,628	1,029									
3	1995	2,635	793	21,737	1,628	1,029									
4	1996	2,635	804	21,737	1,628	1,029									
5	1997	2,635	813	21,737	1,678	1,070									
6	1998	2,635	829	21,737	1,720	1,070									
7	1999	2,635	834	21,737	1,765	1,108									
8	2000	2,635	840	21,737	1,802	1,151									
9	2001	2,635	852	21,737	1,887	1,192									
10	2002	2,789	867	21,737	1,922	1,223									
11	2003	2,894	885	21,737	1,986	1,291									
12	2004	2,894	885	21,737	2,053	1,291									
13	2005	2,894	885	21,737	2,129	1,317									
14	2006	2,957	885	21,737	2,129	1,317									
15	2007	3,019	885	21,737	2,129	1,333									
16	2008	3,069	885	21,737	2,129	1,368									
17	2009	3,114	885	21,737	2,129	1,389									
18	2010	3,211	885	21,737	2,129	1,439									

NON-Residential Acres

- indacres
- offacres
- othacres
- retacres
- whsacres

Acres

25,000
20,000
15,000
10,000
5,000
0

1990 1995 2000 2005 2010 2015

Year

Res Acres / Residential Units / RES Density / NON-Res Acres / Non-Res Sq. Ft

Draw AutoShapes

Ready

Arial   12   B I U

A1   =   Year

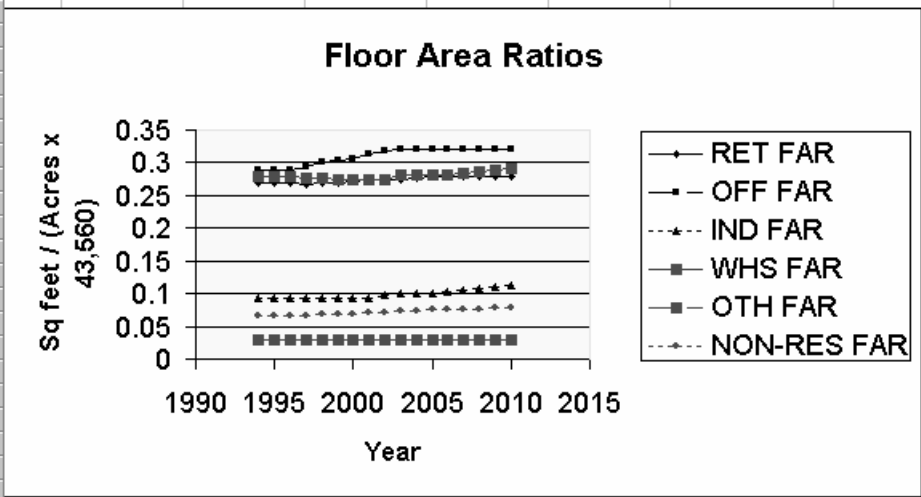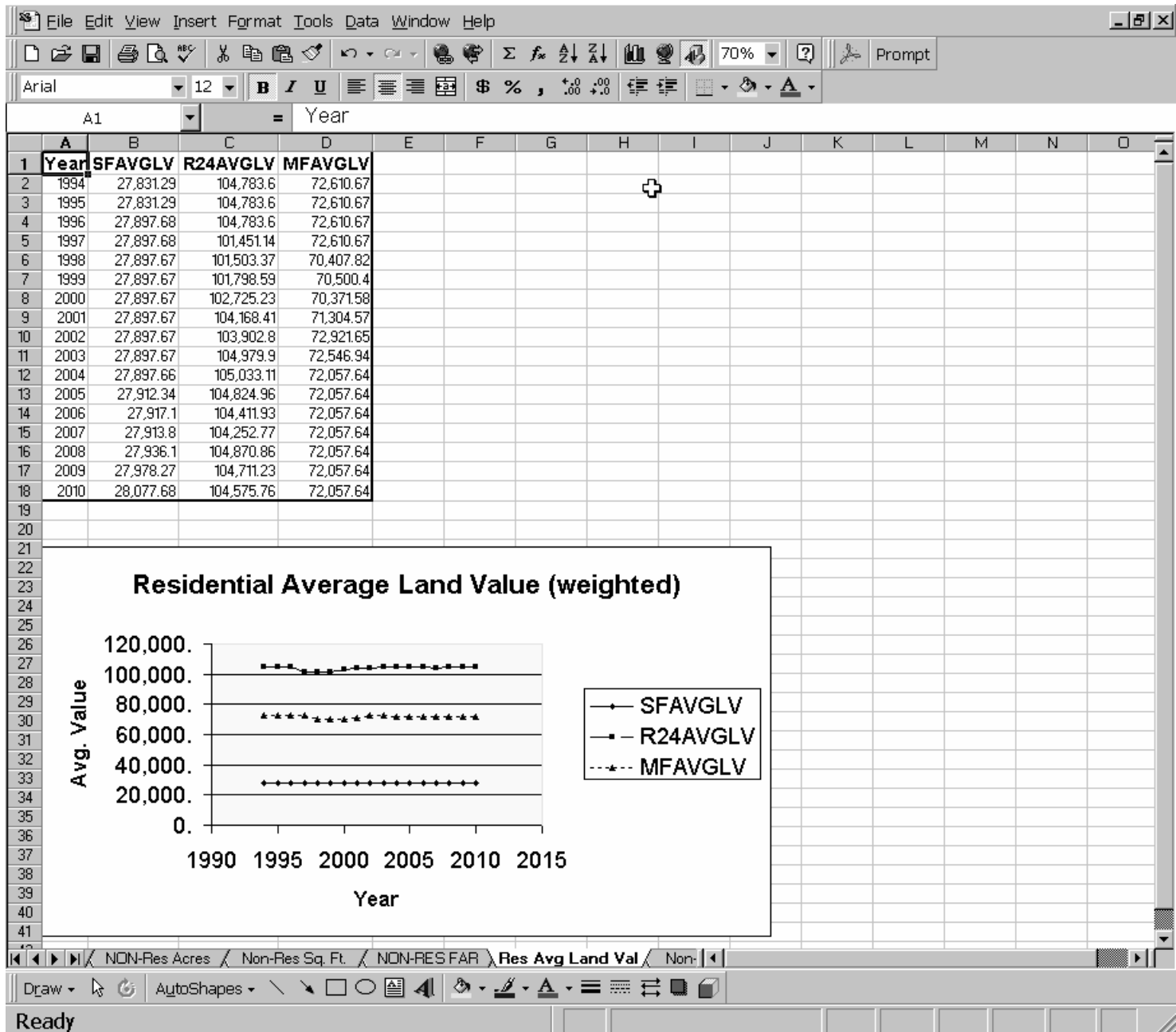|	A	B	C	D	E	F
1	Year	indsqft	offsqft	othsqft	retsqft	whssqft
2	1994	10,755,369	9,961,992	28,012,390	19,031,123	12,559,548
3	1995	10,755,369	9,961,992	28,012,390	19,031,123	12,559,548
4	1996	10,755,369	10,095,389	28,012,390	19,031,123	12,559,548
5	1997	10,755,369	10,380,566	28,012,390	19,581,549	12,930,336
6	1998	10,755,369	10,857,657	28,012,390	20,134,717	12,930,336
7	1999	10,755,369	11,043,665	28,012,390	20,731,734	13,272,953
8	2000	10,755,369	11,229,877	28,012,390	21,310,412	13,711,472
9	2001	10,755,369	11,607,284	28,012,390	22,473,134	14,253,806
10	2002	11,780,802	11,970,227	28,012,390	22,939,522	14,663,422
11	2003	12,757,044	12,314,468	28,012,390	23,759,693	15,766,738
12	2004	12,757,044	12,314,468	28,012,390	24,712,637	15,766,738
13	2005	12,757,044	12,314,468	28,012,390	25,851,994	16,208,622
14	2006	13,341,454	12,314,468	28,012,390	25,851,994	16,208,622
15	2007	13,915,881	12,314,468	28,012,390	25,851,994	16,480,480
16	2008	14,381,445	12,314,468	28,012,390	25,851,994	17,076,472
17	2009	14,791,768	12,314,468	28,012,390	25,851,994	17,451,362
18	2010	15,691,107	12,314,468	28,012,390	25,851,994	18,254,448

Non-Residential Square Feet
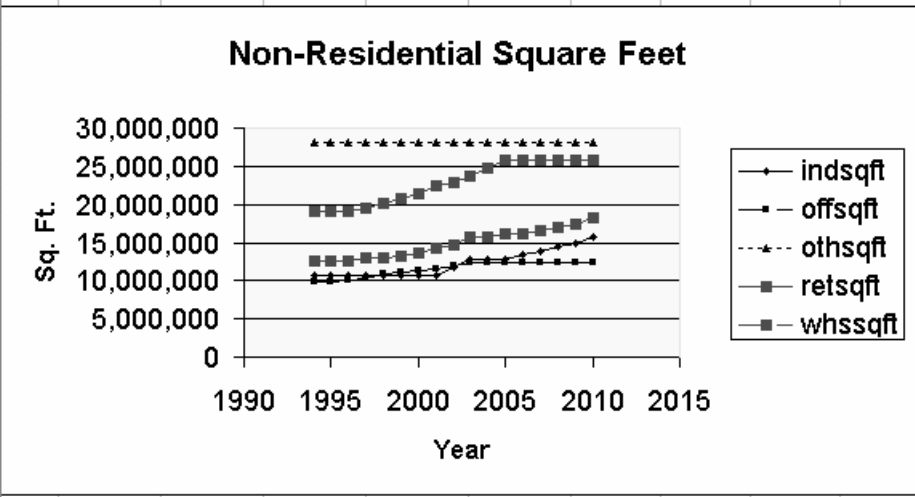
Residential Units / RES Density / NON-Res Acres / Non-Res Sq. Ft. / NON-RE

Draw   AutoShapes

Ready

Arial | 12 | **B** *I* U

A1 = Year

	A	B	C	D	E	F	G
1	Year	RET FAR	OFF FAR	IND FAR	WHS FAR	OTH FAR	NON-RES FAR
2	1994	0.268387424	0.28826968	0.093716522	0.280204422	0.029584095	0.066274909
3	1995	0.268387424	0.28826968	0.093716522	0.280204422	0.029584095	0.066274909
4	1996	0.268387424	0.288421537	0.093716522	0.280204422	0.029584095	0.06636065
5	1997	0.267834359	0.293082037	0.093716522	0.277466928	0.029584095	0.067112342
6	1998	0.268777148	0.300821283	0.093716522	0.277466928	0.029584095	0.067821029
7	1999	0.269728039	0.304165063	0.093716522	0.27511383	0.029584095	0.06853022
8	2000	0.271527778	0.306758014	0.093716522	0.273412913	0.029584095	0.069297387
9	2001	0.273370054	0.312930495	0.093716522	0.274536131	0.029584095	0.070650472
10	2002	0.27402809	0.316978977	0.096979976	0.275198739	0.029584095	0.071889417
11	2003	0.274615852	0.319609811	0.101193974	0.280350172	0.029584095	0.073838548
12	2004	0.276351171	0.319609811	0.101193974	0.280350172	0.029584095	0.07442595
13	2005	0.278732544	0.319609811	0.101193974	0.282505095	0.029584095	0.075416279
14	2006	0.278732544	0.319609811	0.1035733	0.282505095	0.029584095	0.075714682
15	2007	0.278732544	0.319609811	0.105815238	0.2837981	0.029584095	0.076179419
16	2008	0.278732544	0.319609811	0.107565372	0.286595013	0.029584095	0.076792579
17	2009	0.278732544	0.319609811	0.10906098	0.288350304	0.029584095	0.077236043
18	2010	0.278732544	0.319609811	0.112195154	0.291168638	0.029584095	0.078179402

Floor Area Ratios

RES Density / NON-Res Acres / Non-Res Sq. Ft. / **NON-RES FAR** / Res Avg La

Draw ▾ AutoShapes ▾

Ready

	Arial	12	B I U					$ % ,								

A1 = Year

	A	B	C	D	E	F	G
1	Year	INDAVGLV	WHSAVGLV	RETAVGLV	OFFAVGLV	OTHAVGLV	VACAVGLV
2	1994	18,441.17	50,512.64	146,538.47	117,969.57	15,366.99	15,109.46
3	1995	18,441.17	50,512.64	146,538.47	117,969.57	15,366.99	15,109.45
4	1996	18,441.17	50,512.64	146,538.47	116,792.69	15,366.99	15,823.35
5	1997	18,441.17	49,221.98	143,027.49	117,400.39	15,366.99	15,932.1
6	1998	18,441.17	49,221.98	141,226.32	118,774.99	15,366.99	15,813.28
7	1999	18,441.17	48,113.63	140,222.9	119,686.99	15,366.99	15,606.21
8	2000	18,441.17	47,076.81	140,148.	119,854.41	15,366.99	15,428.08
9	2001	18,441.17	46,714.66	137,743.13	121,306.96	15,366.99	14,956.32
10	2002	18,499.97	46,533.25	136,834.41	121,276.58	15,366.99	14,457.79
11	2003	19,006.53	47,192.92	134,718.73	120,668.45	15,366.99	13,988.19
12	2004	19,006.53	47,192.92	133,768.44	120,668.45	15,366.99	13,839.23
13	2005	19,006.53	47,533.	132,768.45	120,668.45	15,366.99	13,727.99
14	2006	19,292.46	47,533.	132,768.45	120,668.45	15,366.99	13,874.12
15	2007	19,561.86	47,852.14	132,768.45	120,668.45	15,366.99	14,005.63
16	2008	19,772.28	48,361.05	132,768.45	120,668.45	15,366.99	14,006.74
17	2009	19,952.11	48,750.	132,768.45	120,668.45	15,366.99	13,532.41
18	2010	20,328.85	48,991.26	132,768.45	120,668.45	15,366.99	12,223.15

Non-Residential Average Land Value (weighted)
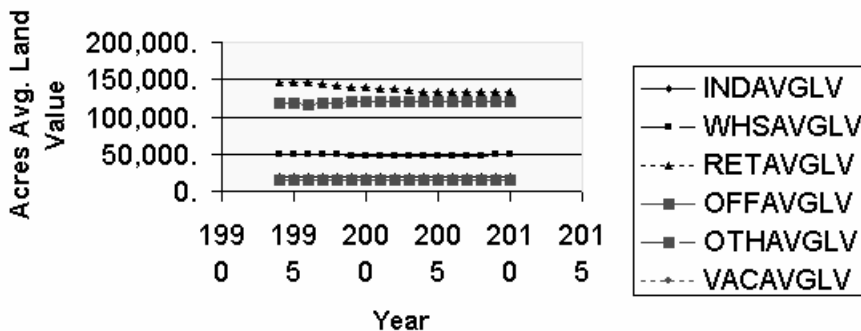
Acres Avg. Land Value

200,000.
150,000.
100,000.
50,000.
0.

Year: 1990 1995 2000 2005 2010 2015

Legend:
- INDAVGLV
- WHSAVGLV
- RETAVGLV
- OFFAVGLV
- OTHAVGLV
- VACAVGLV

NON-RES FAR / Res Avg Land Val \ Non-Res Avg Land Val / Res Avg Tot Val

Draw AutoShapes

Ready

Arial   12

A1   =   Year

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Year	SFAVGTOTV	R24AVGTOTV	MFAVGTOTV										
2	1994	137,520.95	50,365.58	27,546.22										
3	1995	137,520.95	50,365.58	27,546.22										
4	1996	152,513.4	50,365.58	27,546.22										
5	1997	152,513.4	51,038.56	27,546.22										
6	1998	152,513.4	51,244.27	28,154.41										
7	1999	152,513.39	51,282.65	28,545.96										
8	2000	152,513.39	51,428.89	28,878.64										
9	2001	152,513.39	51,798.9	28,967.1										
10	2002	152,513.39	51,888.08	29,081.07										
11	2003	152,513.39	52,009.36	29,033.84										
12	2004	152,513.39	52,208.	28,794.56										
13	2005	152,436.61	52,305.84	28,794.56										
14	2006	152,230.63	52,396.83	28,794.56										
15	2007	151,830.67	52,460.56	28,794.56										
16	2008	151,254.11	52,458.15	28,794.56										
17	2009	150,709.62	52,527.87	28,794.56										
18	2010	150,265.71	52,571.79	28,794.56										

Residential Average Total Value (weighted)

Res Avg Land Val   Non-Res Avg Land Val   Res Avg Tot Val   Non-Res Avg T

Draw   AutoShapes

Ready

Arial   12   **B** *I* U $ % ,

A1   =   Year

	A	B	C	D	E	F	G	H	I	J	K	L
1	Year	INDAVGTOTV	WHSAVGTOTV	RETAVGTOTV	OFFAVGTOTV	OTHAVGTOTV						
2	1994	48.66	20.48	35.45	45.02	46.72						
3	1995	48.66	20.48	35.45	45.02	46.72						
4	1996	48.66	20.48	35.45	55.11	46.72						
5	1997	48.66	20.74	37.47	57.75	46.72						
6	1998	48.66	20.74	37.78	59.69	46.72						
7	1999	48.66	20.98	39.05	59.83	46.72						
8	2000	48.66	21.28	39.26	60.37	46.72						
9	2001	48.66	21.6	39.38	60.79	46.72						
10	2002	51.5	21.94	39.24	60.7	46.72						
11	2003	52.3	22.54	38.92	59.97	46.72						
12	2004	52.3	22.54	38.4	59.97	46.72						
13	2005	52.3	22.71	37.82	59.97	46.72						
14	2006	52.73	22.71	37.82	59.97	46.72						
15	2007	53.11	22.79	37.82	59.97	46.72						
16	2008	53.4	22.9	37.82	59.97	46.72						
17	2009	53.64	22.99	37.82	59.97	46.72						
18	2010	54.12	22.95	37.82	59.97	46.72						

Non-Residential Average Total Value (weighted)

Non-Res Avg Land Val / Res Avg Tot Val / **Non-Res Avg Tot Val** / Hholds by ir

Draw   AutoShapes

Ready

Arial 12
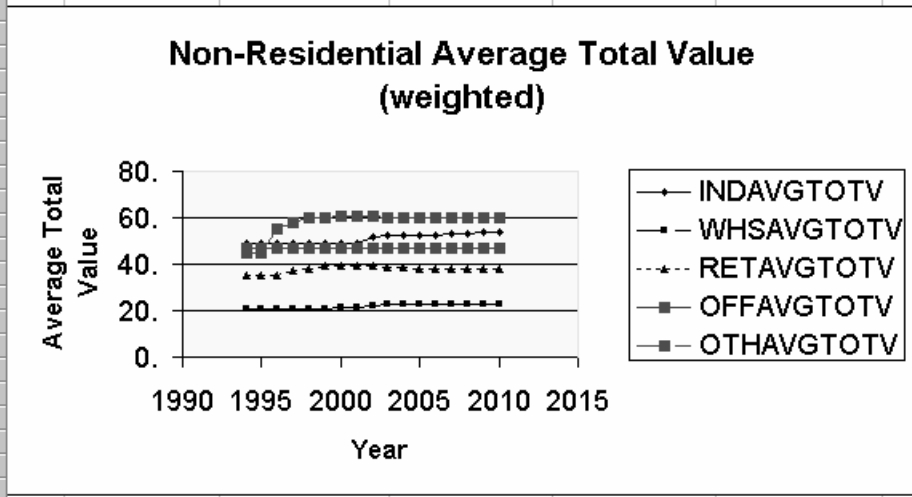
A1 = Year

	A	B	C	D	E
1	Year	hhinc1	hhinc2	hhinc3	hhinc4
2	1994	21,583	26,764	19,775	3,486
3	1995	21,756	26,888	19,920	3,513
4	1996	22,026	27,233	20,188	3,563
5	1997	22,368	27,589	20,509	3,613
6	1998	22,687	27,913	20,879	3,679
7	1999	23,001	28,285	21,247	3,747
8	2000	23,335	28,646	21,619	3,834
9	2001	23,663	28,985	21,996	3,922
10	2002	24,048	29,437	22,381	3,988
11	2003	24,395	29,817	22,721	4,069
12	2004	24,717	30,246	23,072	4,132
13	2005	25,037	30,665	23,503	4,211
14	2006	25,408	31,118	23,878	4,263
15	2007	25,766	31,567	24,256	4,338
16	2008	26,191	32,043	24,723	4,403
17	2009	26,596	32,537	25,130	4,477
18	2010	27,016	32,982	25,568	4,565

Number of Households

Res Avg Tot Val / Non-Res Avg Tot Val / Hholds by inc / Bus Estab / Subtotal

Draw AutoShapes

Ready

Arial   12   B I U $ % ,   70%   Prompt

A1   =   Year

	A	B	C	D	E
1	Year	basicest	govedest	retailest	servest
2	1994	1,623	255.	1,345	2,792.
3	1995	1,698	248.	1,358	2,856.
4	1996	1,746	244.	1,368	2,886.
5	1997	1,772	236.	1,365	2,934.
6	1998	1,832	226.	1,358	2,979.
7	1999	1,890	218.	1,378	3,055.
8	2000	1,941	210.	1,408	3,119.
9	2001	1,977	203.	1,418	3,178.
10	2002	2,043	198.	1,428	3,219.
11	2003	2,115	190.	1,449	3,267.
12	2004	2,186	185.	1,464	3,290.
13	2005	2,261	179.	1,468	3,339.
14	2006	2,339	175.	1,491	3,379.
15	2007	2,386	171.	1,488	3,432.
16	2008	2,451	166.	1,498	3,514.
17	2009	2,507	162.	1,495	3,567.
18	2010	2,576	156.	1,497	3,624.

Business Establishments

Sheets: Res Avg Tot Val / Non-Res Avg Tot Val / Hholds by inc / **Bus Estab** / Subtotal

Draw ▾ AutoShapes ▾

Ready

Status

- Beta Version of UrbanSim Completed
- Licensed as 'Free Software' Under GNU General Public License
  - Intended to Facilitate Collaborative Development
  - Intended to Prevent Proprietary Restriction
- Web Site Established for Information and Access: http://urbansim.org

Conclusions

- Prototype Model 1st Step in New Generation Land Use Model

- Cross-sectional Calibration Complete
  - Results Generally Promising
  - Some Areas Need Further Development

- Next Comes Longitudinal Calibration

Conclusions

- Remaining Issues for 2nd Gen Models:
  - Higher Level Travel Model Integration
  - State/Substate/Metropolitan Integration
- Software Rewrite as Production Code
  - Same as Commercial Software Process
  - Need Solid Foundation for Re-Use
- Need Substantial Testing and Careful Phasing into Policy Application