Evaluations of **Land Use-Transport** Systems: Incorporating the **Environment & Equity**
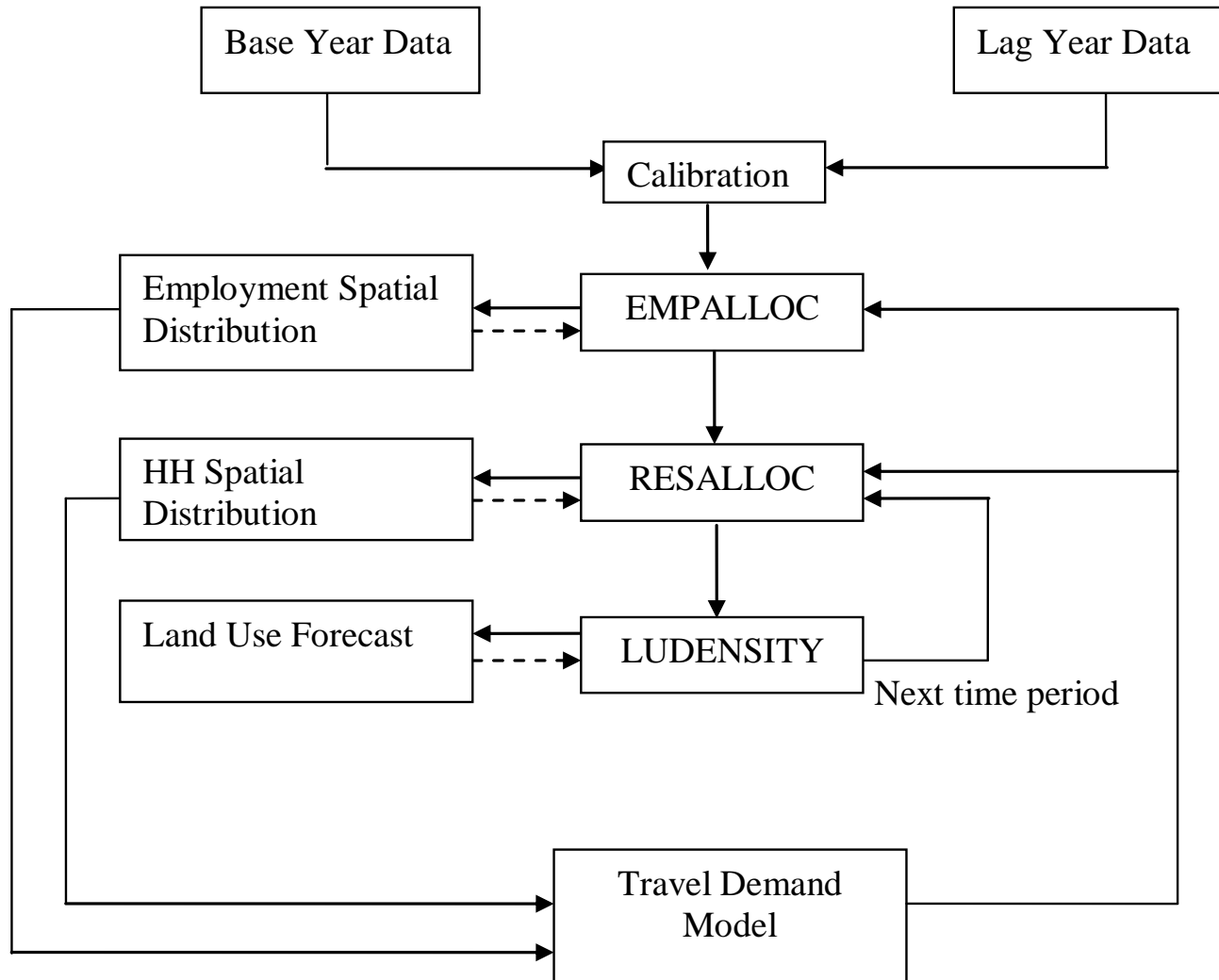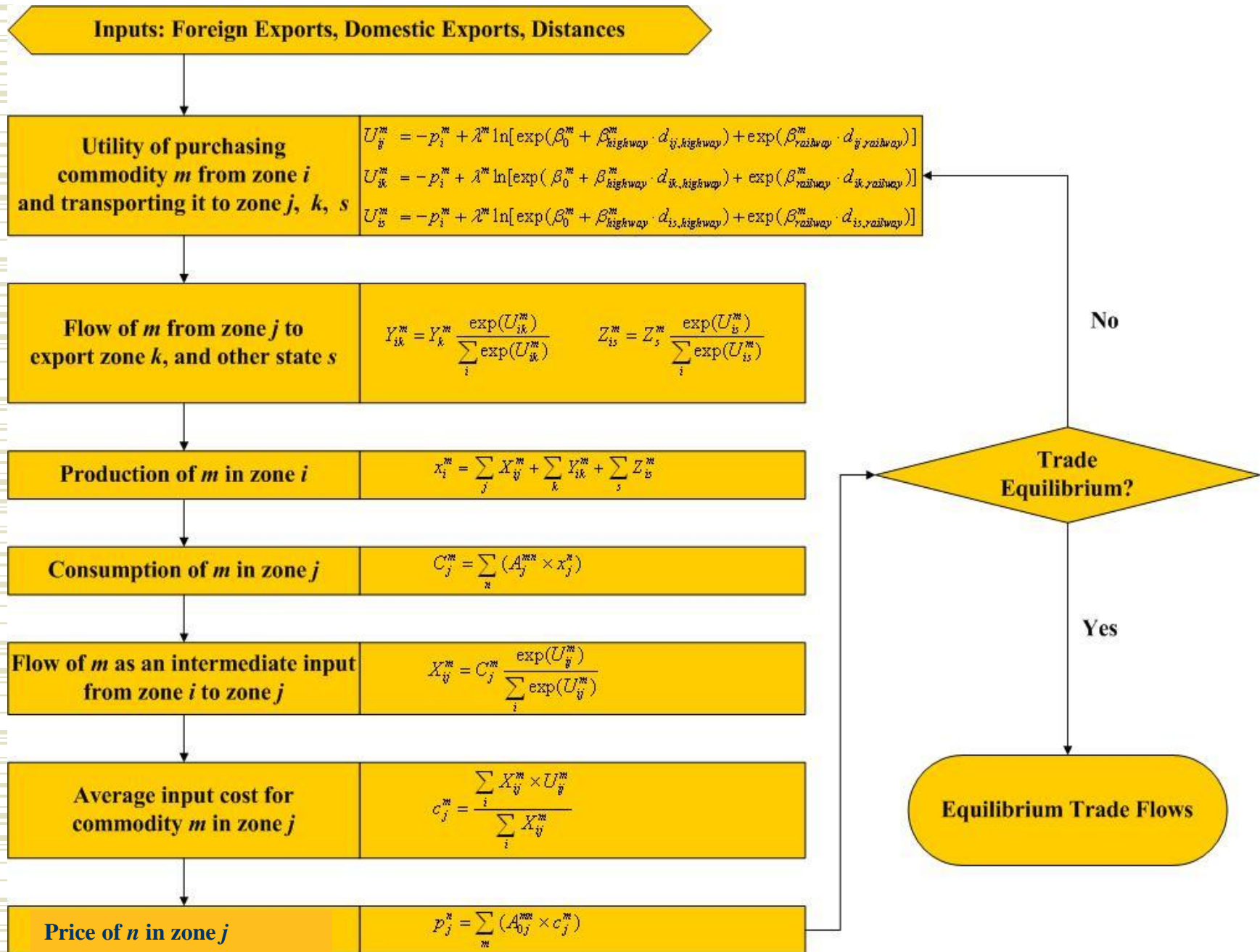

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Land Use-Transport Models

- What do these look like, & what do they provide?
- Land use models are a series of steps, from generation of jobs & households to their allocation among zones or parcels.
- Some also provide estimates of building types & sizes, industrial production, & property prices.
- Land use steps are typically externally linked to travel models, which estimate traveler flows between zones & on links by time of day.
- PECAS, MEPLAN, TRANUS & RUBMRIO (SIOs), MUSSA/CubeLand, DRAM/EMPAL, DELTA

The Simplest Model Logic ...

Inputs: Foreign Exports, Domestic Exports, Distances

Utility of purchasing commodity m from zone i and transporting it to zone j, k, s

$$U_{ij}^m = -p_i^m + \lambda^m \ln[\exp(\beta_0^m + \beta_{highway}^m \cdot d_{ij,highway}) + \exp(\beta_{railway}^m \cdot d_{ij,railway})]$$

$$U_{ik}^m = -p_i^m + \lambda^m \ln[\exp(\beta_0^m + \beta_{highway}^m \cdot d_{ik,highway}) + \exp(\beta_{railway}^m \cdot d_{ik,railway})]$$

$$U_{is}^m = -p_i^m + \lambda^m \ln[\exp(\beta_0^m + \beta_{highway}^m \cdot d_{is,highway}) + \exp(\beta_{railway}^m \cdot d_{is,railway})]$$

Flow of m from zone j to export zone k, and other state s

$$Y_{ik}^m = Y_k^m \frac{\exp(U_{ik}^m)}{\sum_i \exp(U_{ik}^m)} \qquad Z_{is}^m = Z_s^m \frac{\exp(U_{is}^m)}{\sum_i \exp(U_{is}^m)}$$

Production of m in zone i

$$x_i^m = \sum_j X_{ij}^m + \sum_k Y_{ik}^m + \sum_s Z_{is}^m$$

Consumption of m in zone j

$$C_j^m = \sum_n (A_j^{mn} \times x_j^n)$$

Flow of m as an intermediate input from zone i to zone j

$$X_{ij}^m = C_j^m \frac{\exp(U_{ij}^m)}{\sum_i \exp(U_{ij}^m)}$$

Average input cost for commodity m in zone j

$$c_j^m = \frac{\sum_i X_{ij}^m \times U_{ij}^m}{\sum_i X_{ij}^m}$$

Price of n in zone j

$$p_j^n = \sum_m (A_{0j}^{mn} \times c_j^m)$$

Trade Equilibrium?

No

Yes

Equilibrium Trade Flows

Example Inputs

- Networks (distances, capacities, link performance functions)
- Zones (& parcels)
- Jobs & households (by type, by location)
- Land use (acres by type by location)
- Vehicle types (by model year)
- Temperature, humidity, %hot soaks, ….

Networks: DFW's 31,992 links
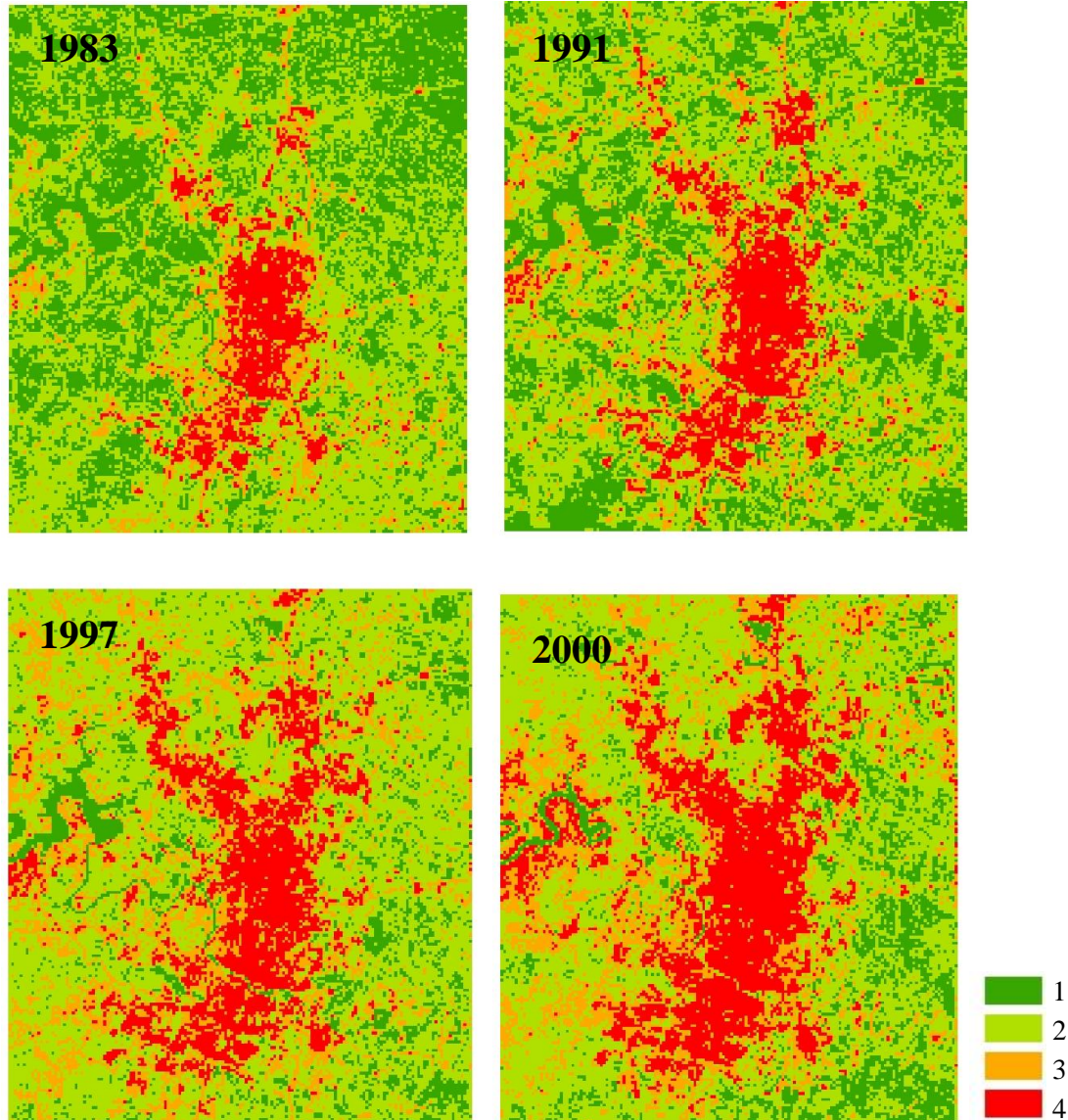
Land Use: Austin's Undeveloped Parcels
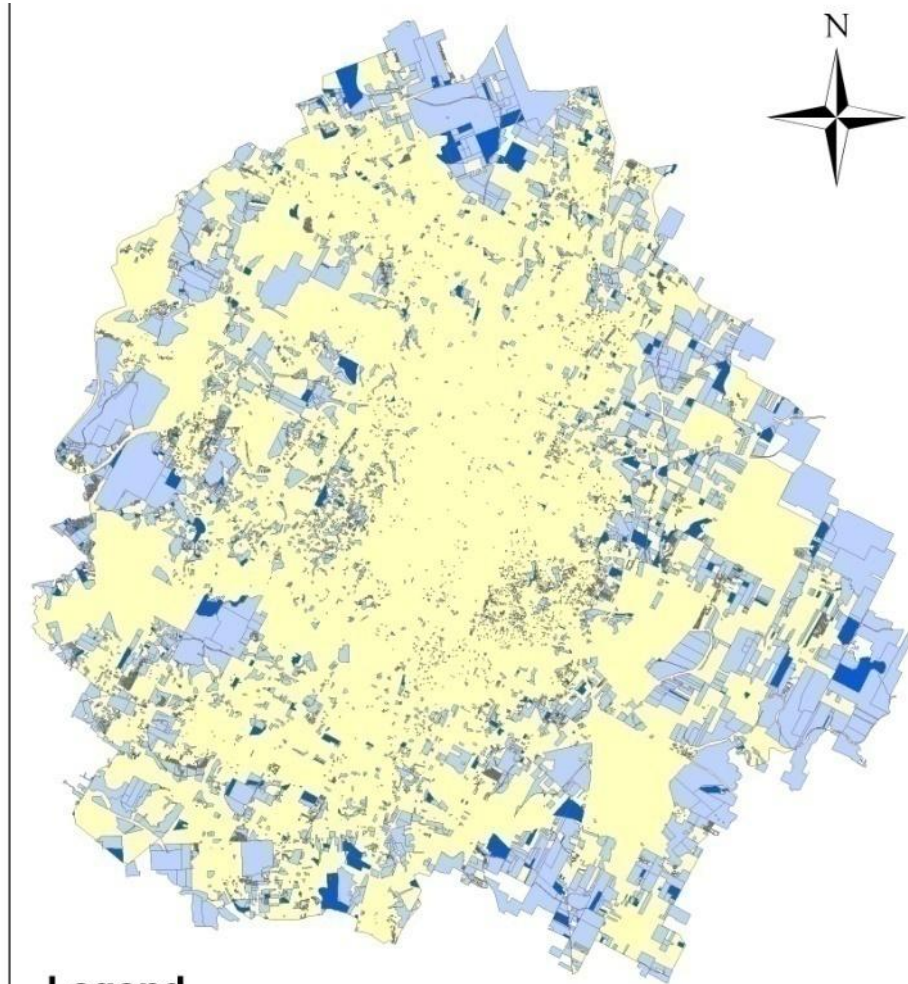
Legend
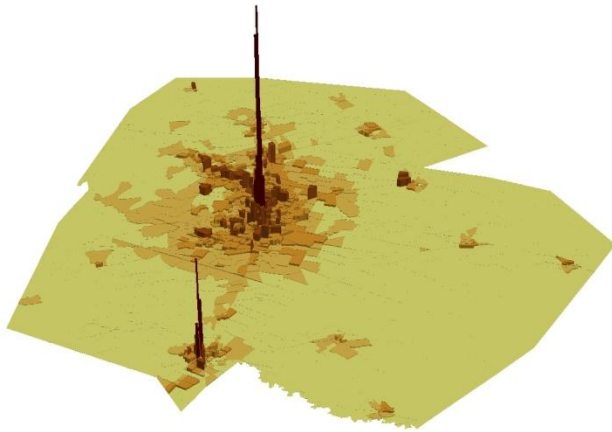- 10 Percent Sample
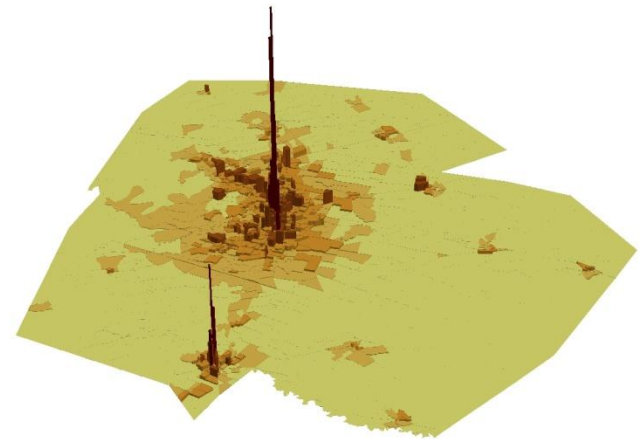- 2000 Undeveloped Parcels
- Study Area

Land Use Intensity: Austin

Example Outputs

Basic Forecasts:
Austin's Job Densities in 2030

Base Case

Road Pricing
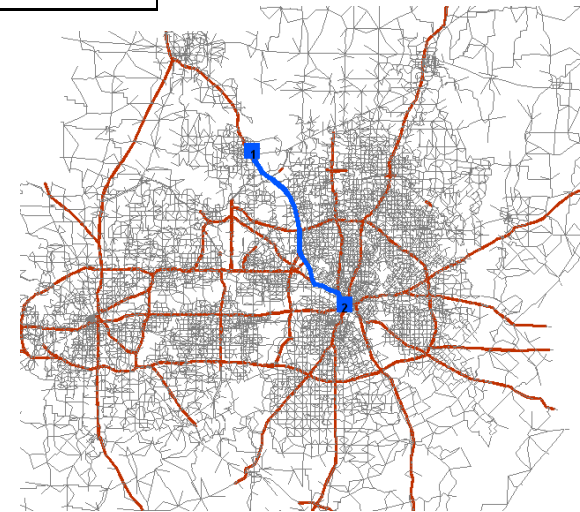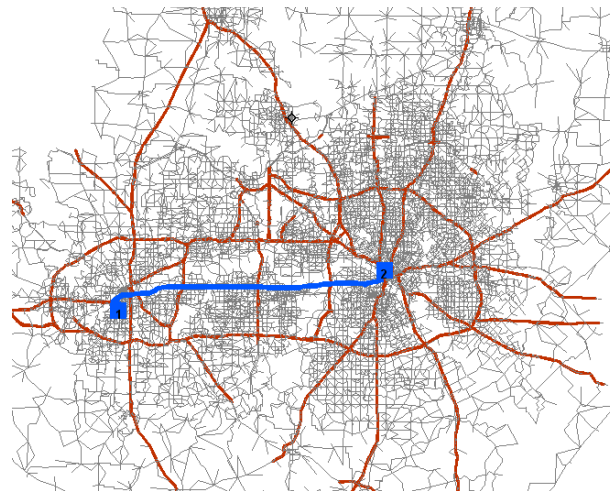(congestion + CO_2)
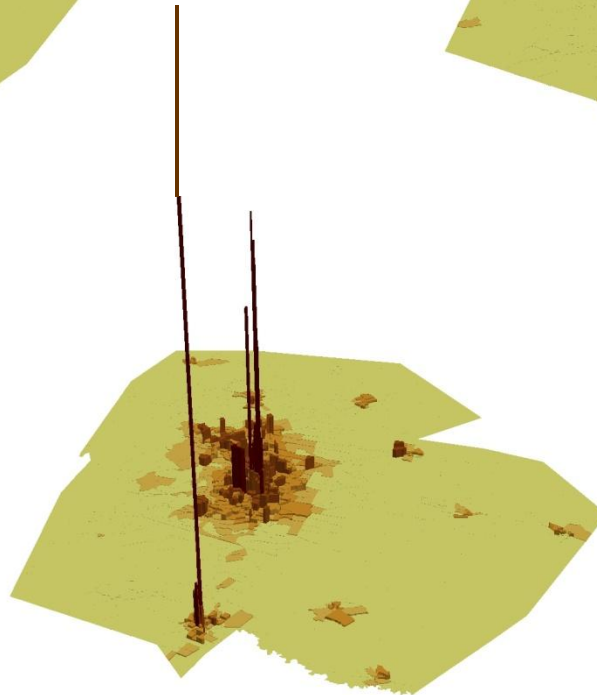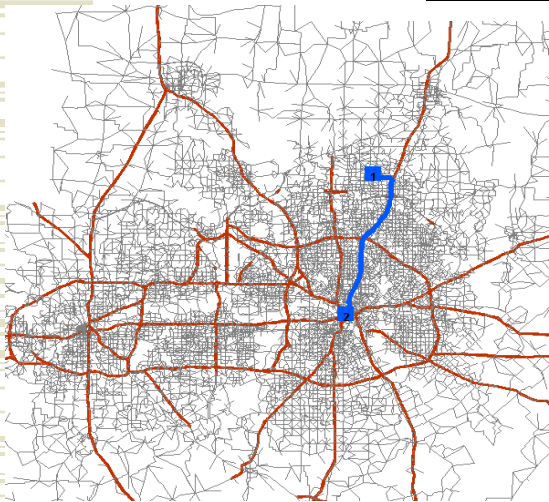
Urban Growth Boundary
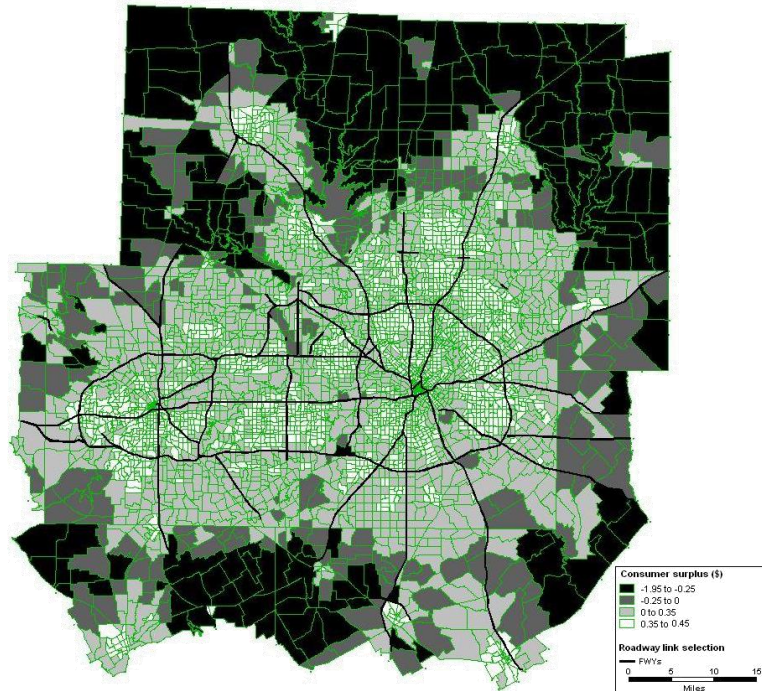
V/C Ratios (DFW)

Speeds (DFW)

VMT by speed
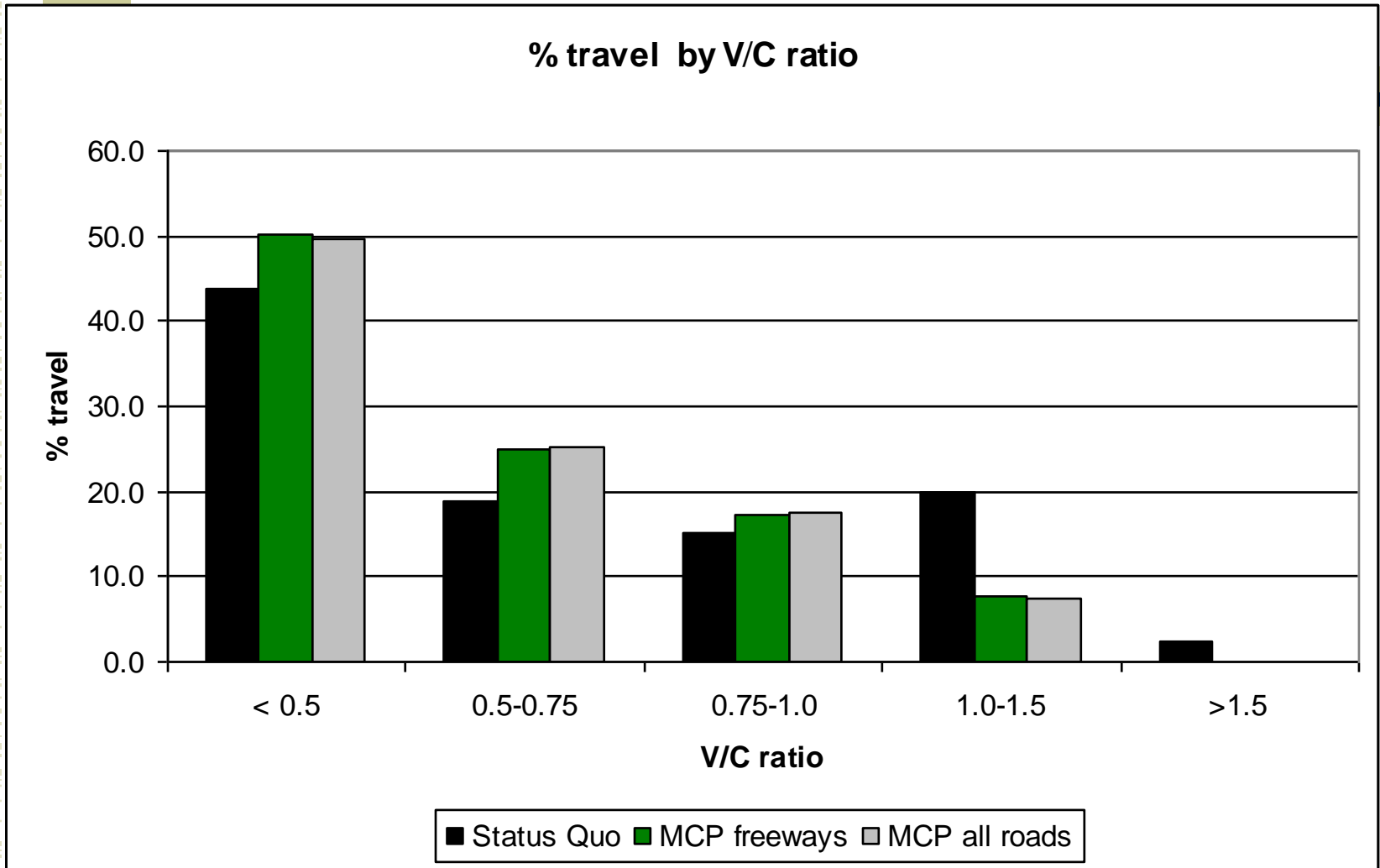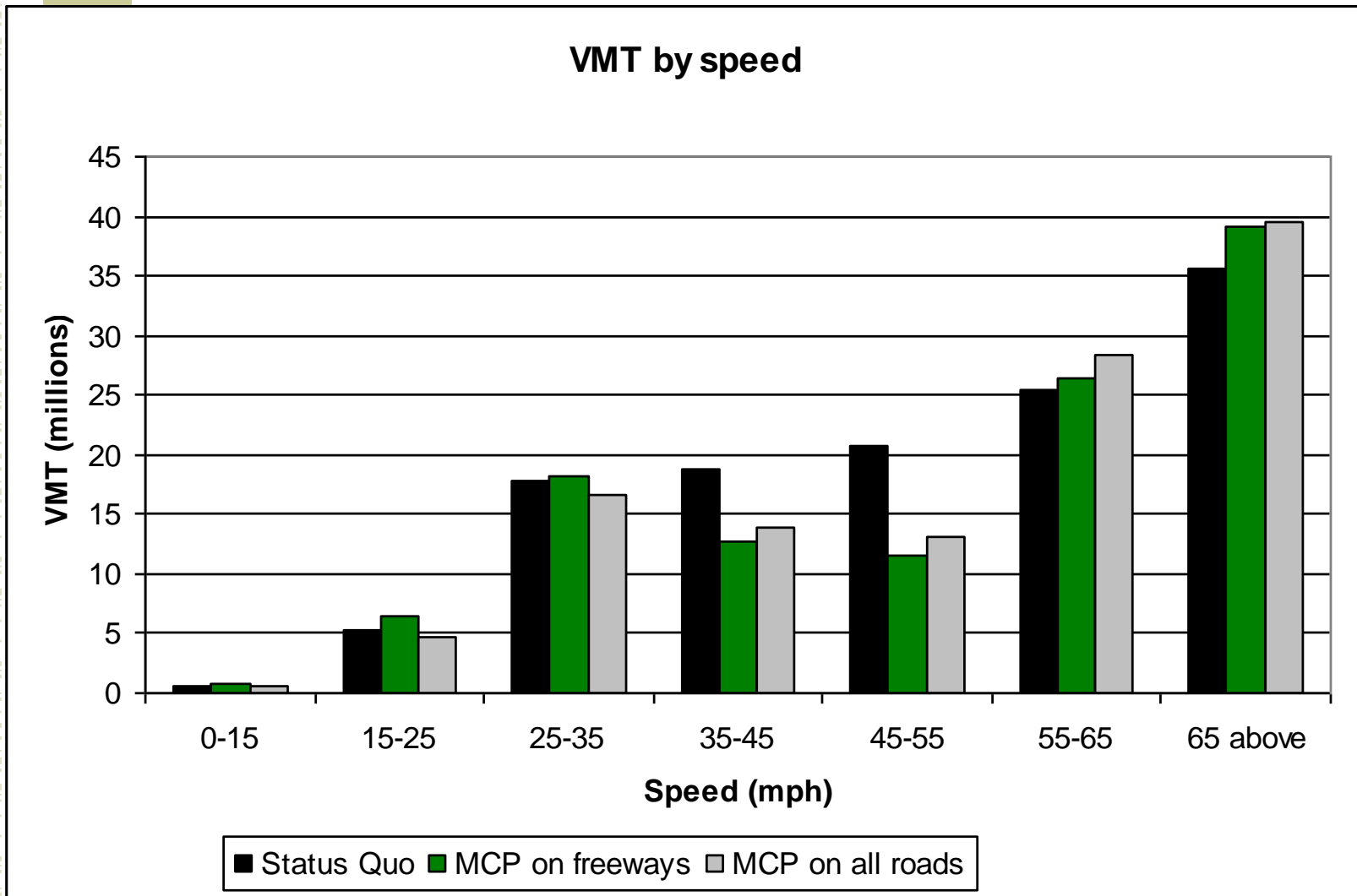
Tolls for Specific **Commutes** (DFW)

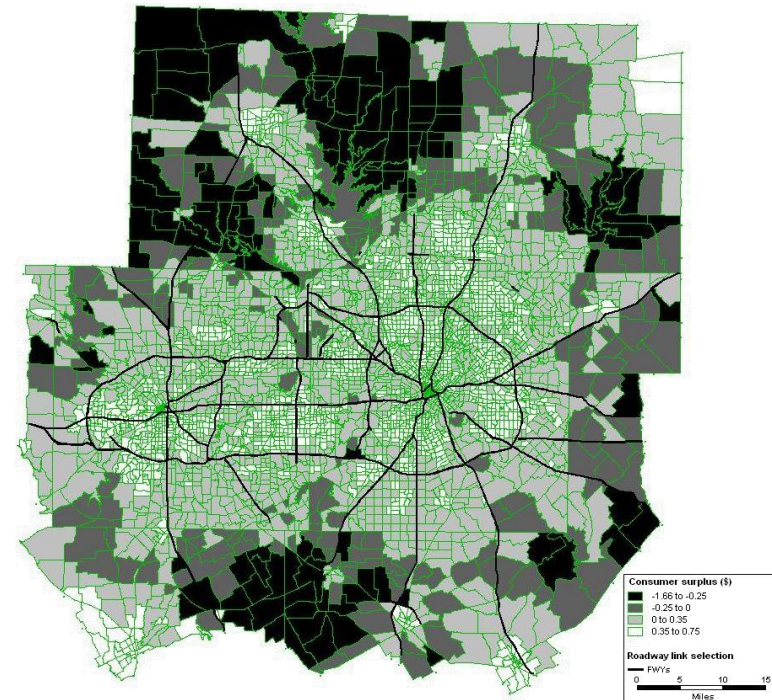| From	Work trip toll ($) /day		Round trip distance (miles)
	Long-term	Short-term	
Plano	3.00	4.00	45
Fort Worth	3.50	7.00	68
Carrollton	2.00	4.00	53
Arlington	2.00	4.00	40
Mesquite	1.00	2.50	26

Welfare Outcomes by Home Location: Medium Income
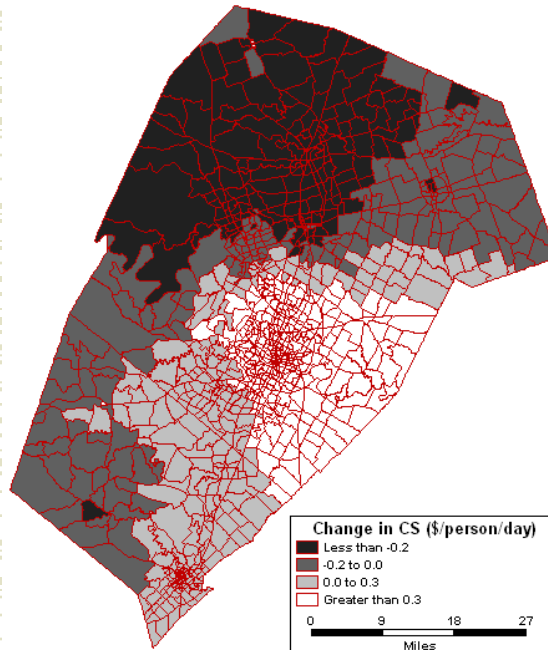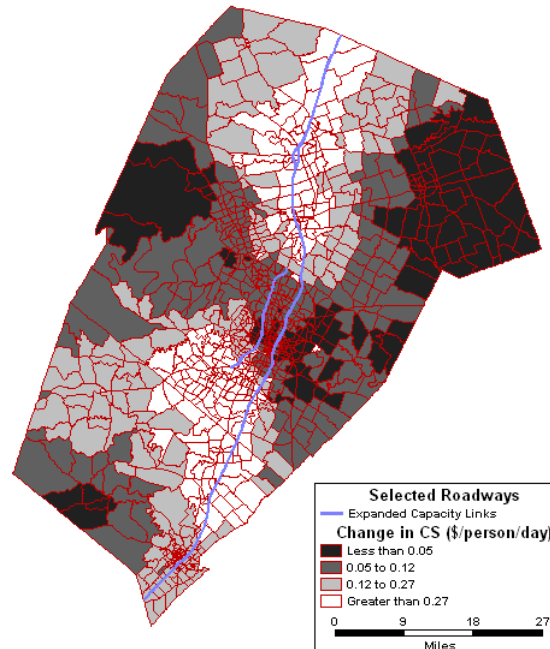
Low vehicle ownership

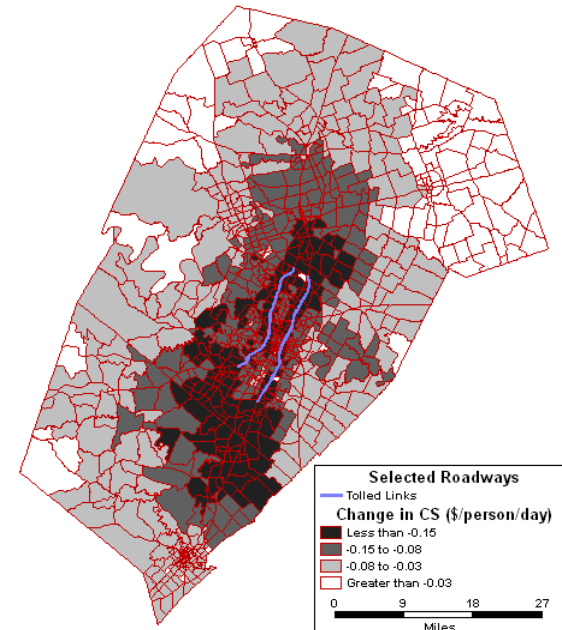High vehicle ownership

Welfare Differences (vs. Base Case)

Centralized Employment

Expanded Capacity

Flat Freeway Tolls

- 10¢/mile tolls on just two congestion sections result in $241k/day revenues & $132k/day welfare loss ($40M net gain per year).

- 95% of all travelers expected to gain if revenues are returned uniformly.

- 10+ years to retire 202 lane-miles cost of capacity expansion via flat tolls…
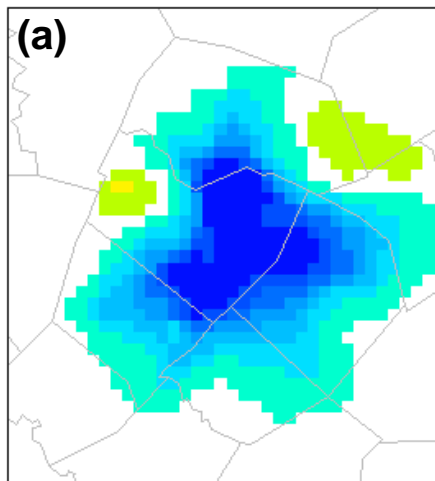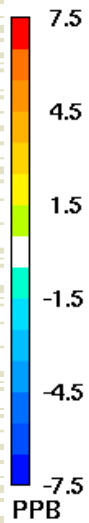 … or 3+ years for the two congested sections' construction.

The Environment

- **Tailpipe Emissions** (flows by speed by roadway & vehicle type + EPA's MOBILE or MOVES or California's EMFAC)

  $\rightarrow$ PM10 & 2.5, NO_X & VOC, CO & CO_2, Toxins (MSATs)

- **Urban Airshed** (photochemical) **Models** (e.g., CAMx) for **Ozone** formation by time of day (recognizing non-road mobile, area, point [e.g., power plants] & biogenic sources)

- **Exposure** Estimates (1 km grids vs. population)

Thank you!

Changes in Anthropogenic Emissions

O3(ECTA) - O3(Basecase)

Changes in Anthropogenic Emissions

O3(ECTA) - O3(Basecase)