Land Use and Transport Modeling for Sustainability Goals

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Outline

- Project Topics
- Land Use & Transport Modeling
  - Background on Land Use/Transport Modeling
  - UrbanSim
  - Example, Salt Lake City, Utah
- Discussion of Assignment 3
- Intro to Assignment 4

Part I

LAND USE/TRANSPORT MODELLING

Prerequisites

For all planning (?)

- A method to foresee future consequences of present actions
- A framework to assess if an outcome is good or bad

Relevant trends

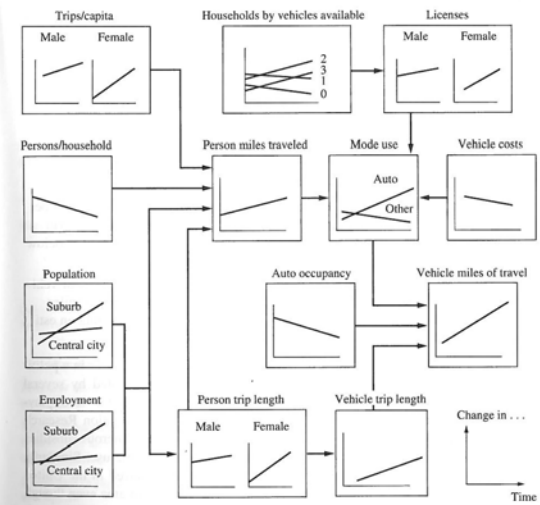
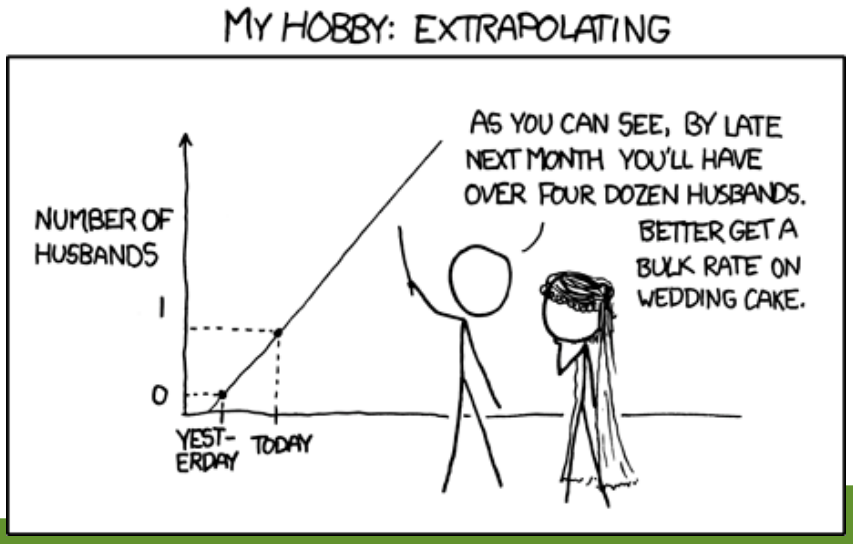


Figure 1.3 Factors influencing urban travel behavior over time
SOURCE: Meyer, 1998
NOTE: The relationships between these variables over the passage of time (denoted by the *x* axes) are represented as being linear. This is done only to illustrate basic relationships and their direction. There is clear evidence that such linearity is not the correct functional form for many of these relationships.

Models

- Trend extrapolation
- Experience
- Transport demand
  - Trips: Frequency, mode, destination
  - Activities: What, where, and when
- Transport supply (assignment)
  - Static equilibrium
  - Dynamic
  - Simulation

Modelling: What we try *not* to do



Travel Demand Modelling

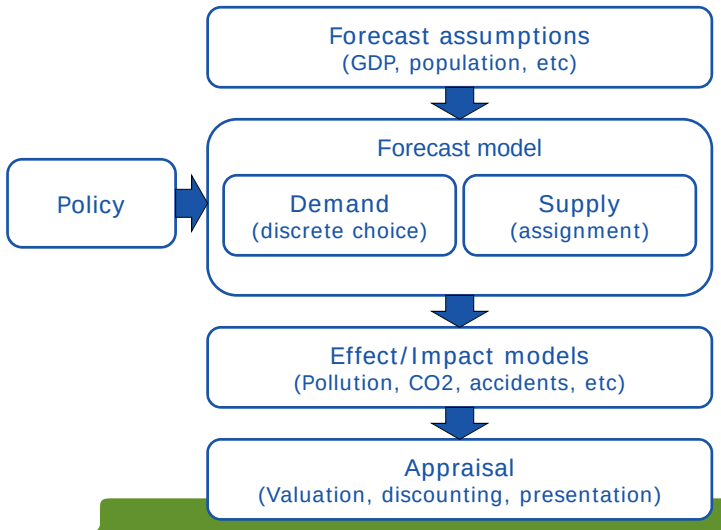
Four-Step Disaggregate Travel Models:

- Trip Generation – how many?
- Trip Distribution – where?
- Mode Choice – how?
- Trip Assignment – what route?

Extensions:

- Joint trip distribution-mode choice
- Auto ownership modelling

Transport models



Model properties

Linear-in-parameters

- E.g. trade-off between time & cost
- Estimated on travel surveys

Policies

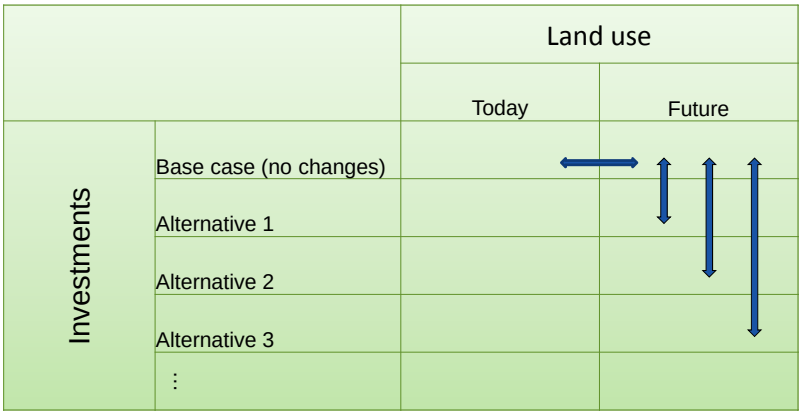
- Infrastructure changes (affects travel time & distance)
- Pricing (transit fares, congestion charges, fuel tax)
- Land use scenarios

Not linear in response!

- Not constant elasticity of substitution
- Non-linear travel times (congestion)

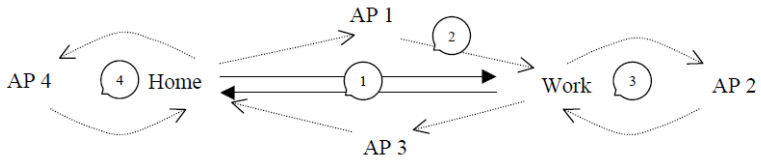
Always a comparison betwen scenarios!

Compared to what?



Activity-Based Travel Modelling

Explicit representation of trip chains:

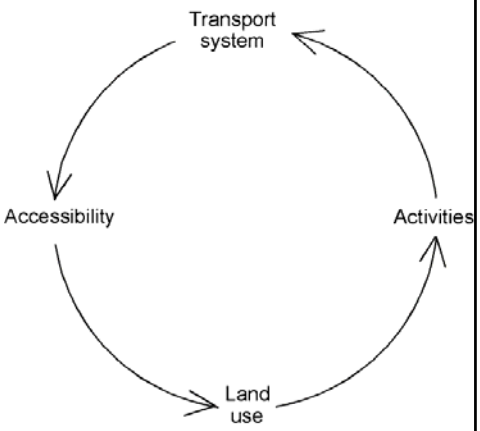


Kuzmyak et al 2012

Integrated Land Use-Transport Modelling

Regional accessibility

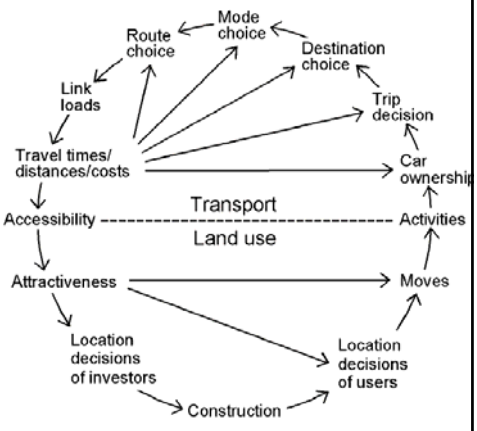
- Household and job location choices
- Density & mix of uses
- Activities
- Travel patterns
- Regional accessibility



Wegener & Fürst 1999

Integrated Land Use-Transport Modelling

More complex interdependencies →



Wegener & Fürst 1999

Urban Modeling Example

URBANSIM

UrbanSim

- Integrated planning and analysis of urban development
- Software-based simulation model
- Open source license
- Led by Paul Waddell (UC Berkeley)

Key Features

- Models Actors Making ***Discrete Choices***:
  - Household Mobility and Location Choice
  - Business Mobility and Location Choice
  - Developer Land Development/ Redevelopment
- Takes Some Things As ***Given***:
  - Governmental Decisions; Population & Jobs
- ***Dynamic*** In Nature:
  - Runs in one-year time-steps
  - Path-dependent (history matters)
  - Adjustment toward equilibrium in long-run

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Key Features (cont.)

- Simulates Incremental Decisions of Urban Actors
- Explicit Representation of:
  - Land, Buildings and Occupants
  - Land Market and Prices
  - Government Policy and Infrastructure

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Policy Inputs

- *Regional Trends:*
  - Total Population and Jobs
- *Development Constraints:*
  - Land use plans
  - Environmental protections
  - Physical constraints (water, steep slopes)
  - Legal constraints
- *Transportation infrastructure*
- *Unique Events*
  - Planned developments
  - Planned future development controls
  - Corporate relocations

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Internal Model Cycle

1. Zone-Specific Accessibilities

2. Synthesis or Deletion of Jobs & Households

3. Identify Jobs & Houses that will Relocate This Year

4. Identify New Locations of Relocating Jobs & Households

5. Simulate Development of New Real Estate

6. Update Estimated Land Values

7. Export Data to MySQL Output Database

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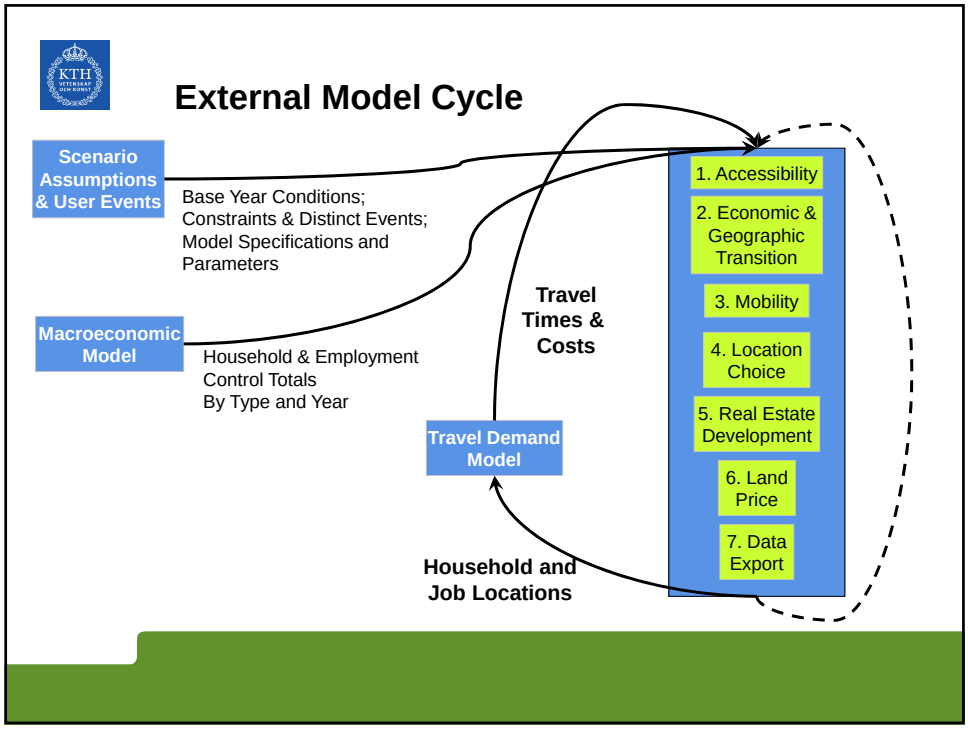
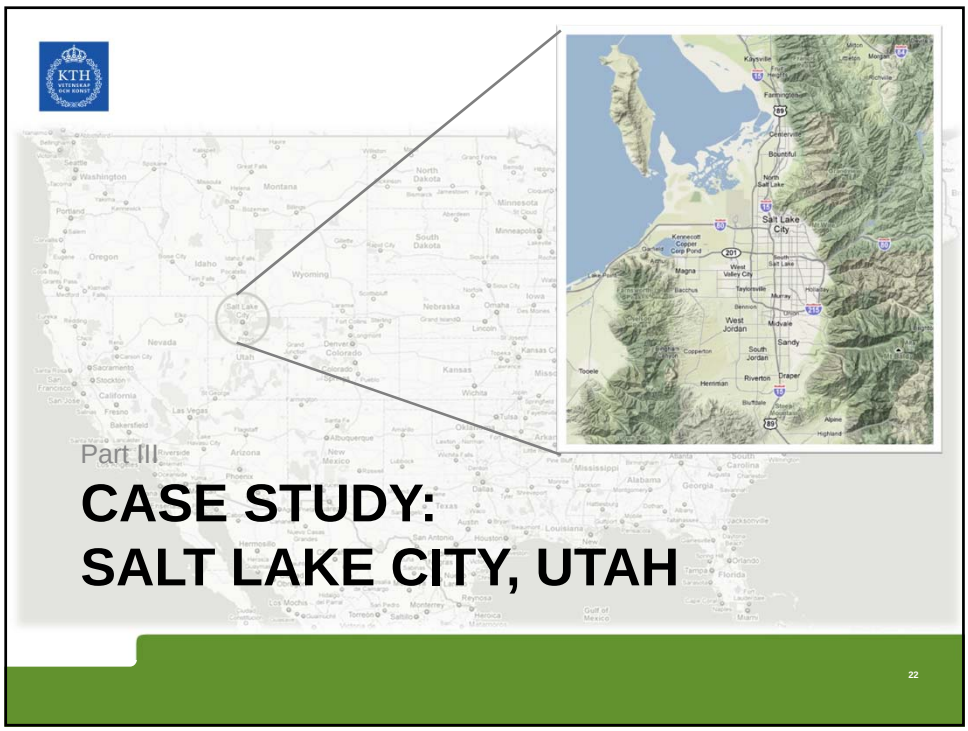

External Model Cycle
Scenario Assumptions & User Events
Base Year Conditions;
Constraints & Distinct Events;
Model Specifications and Parameters
Macroeconomic Model
Household & Employment Control Totals
By Type and Year
Travel Demand Model
Travel Times & Costs
Household and Job Locations
1. Accessibility
2. Economic & Geographic Transition
3. Mobility
4. Location Choice
5. Real Estate Development
6. Land Price
7. Data Export


Part III
CASE STUDY:
SALT LAKE CITY, UTAH
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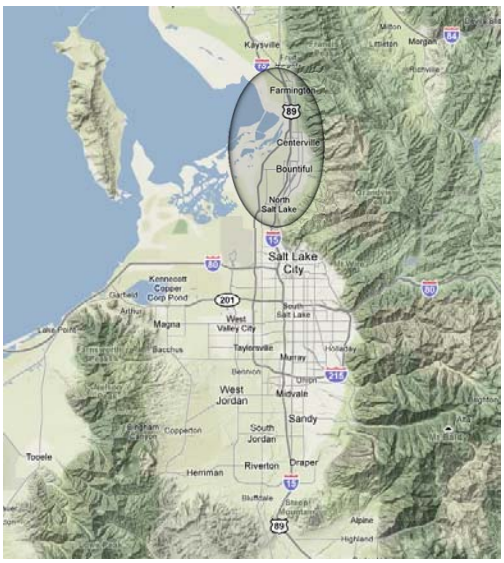
Background

Salt Lake City
- Capital of State of Utah
- Home of “Mormon” Church
- City: 186,000 pop
- Metro: 1,124,000 pop
- Region: 2,238,000 pop

Bounded by Mountains and the Great Salt Lake

Transportation:
- Motorways, Ring-Road
- 31-km Tram (3 lines)



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1996—2000
“Quality Growth Efficiency Tools”

Comprehensive package of regional transport projects
- Light Rail
- Transit-Oriented Development
- New Highway: Legacy Parkway

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1996—2001
Environmental Review

Environmental Impact Statement (EIS)

- Required by law to assess impacts of major projects on the environment

Approved in 2001

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2001
Lawsuit

Sierra Club & Mayor of Salt Lake City
sue the Utah Department of Transport

Argued that EIS was flawed:

- Did not account for **wetlands impacts**
- Did not account for **induced urban development**

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2002 (Winter Olympic Games) Settlement Agreement

Parties Agree to Re-Examine Urban Growth Impacts

- Using **UrbanSim***
- Provided that UrbanSim passes a **Peer Review**

*UrbanSim was already under development

- Interest in land use modeling since 1997
- Experiments with UrbanSim up to 2002

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2003 Peer Review of UrbanSim

Run UrbanSim on the **Base** scenario:

- Existing Long Range Plan (without Legacy Parkway)

Run UrbanSim on some **other** scenarios besides the Legacy Parkway (which was politically sensitive):

- E.g. **Urban Growth Boundary**

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Model Results

LONG RANGE PLAN SCENARIO

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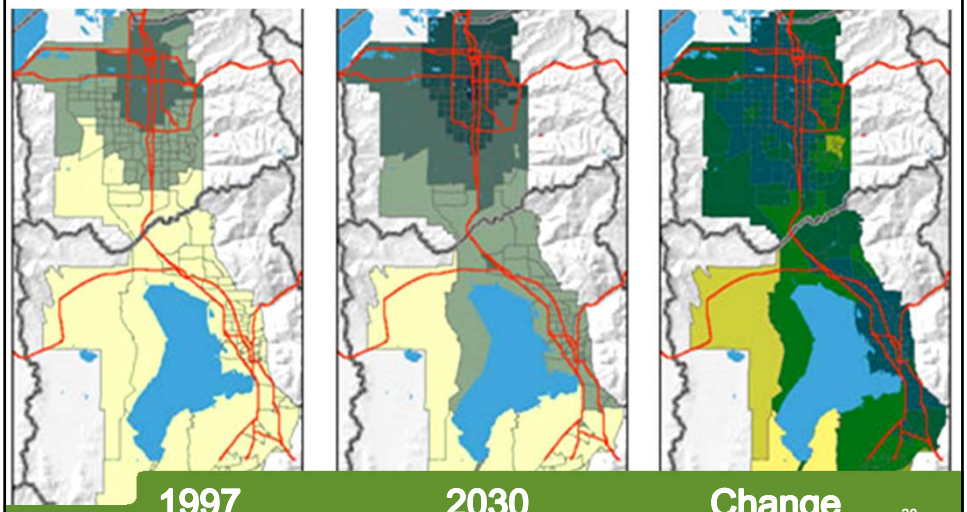
LRP Scenario
Access to Employment



1997 2030 Change

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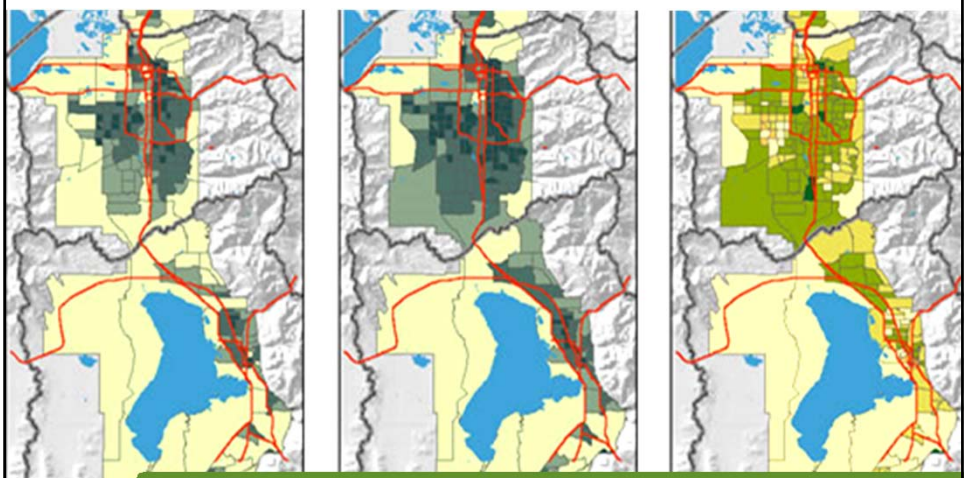
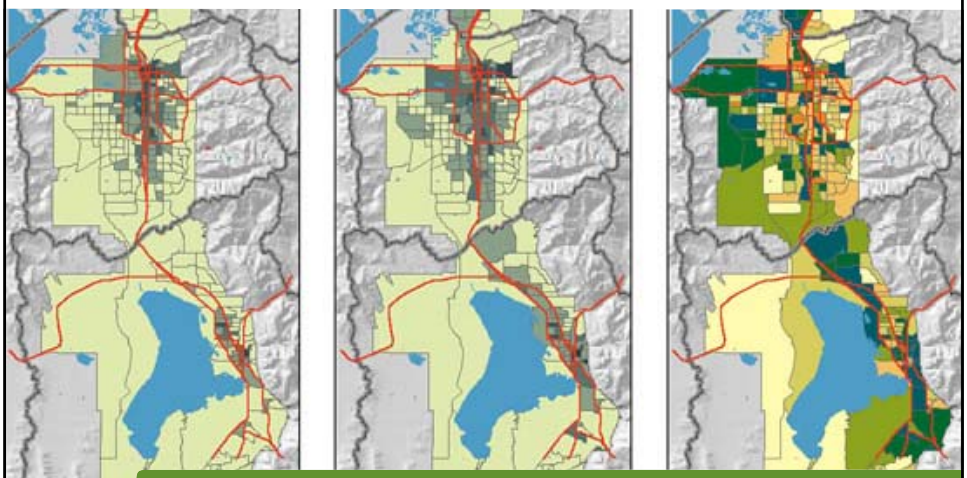
LRP Scenario Population



1997 2030 Change 31

LRP Scenario Employment



1997 2030 Change 32

Model Results

URBAN GROWTH BOUNDARY (UGB) SCENARIO

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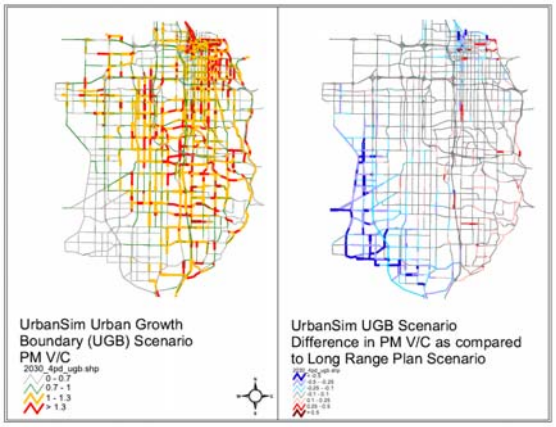
UGB Scenario
Roadway Volume-to-Capacity Ratio



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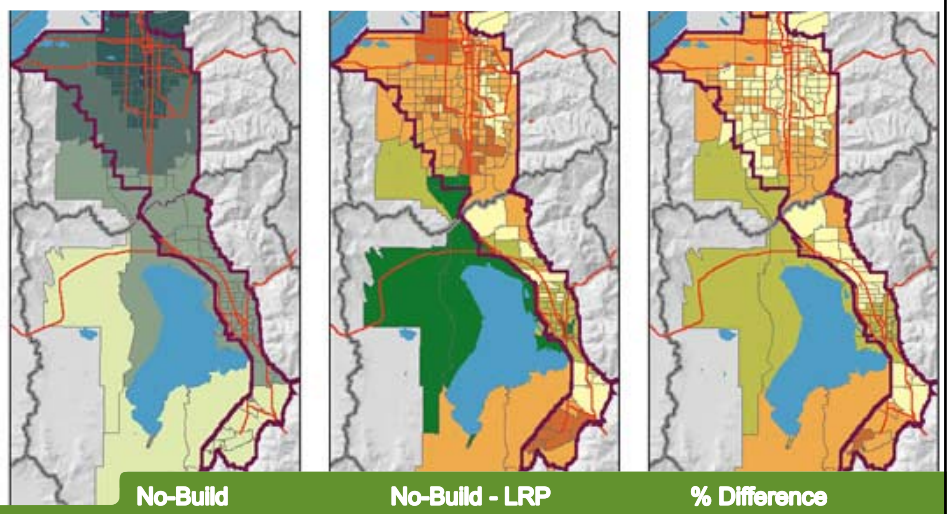
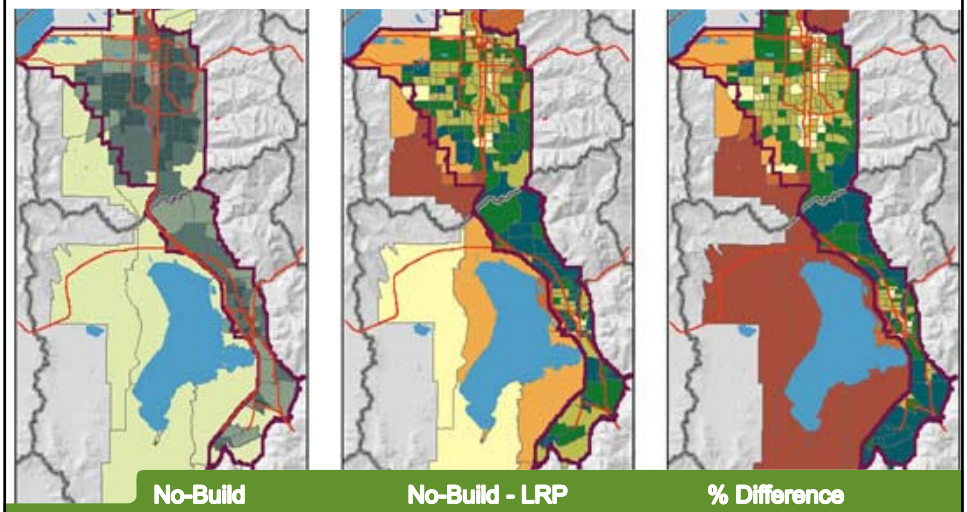
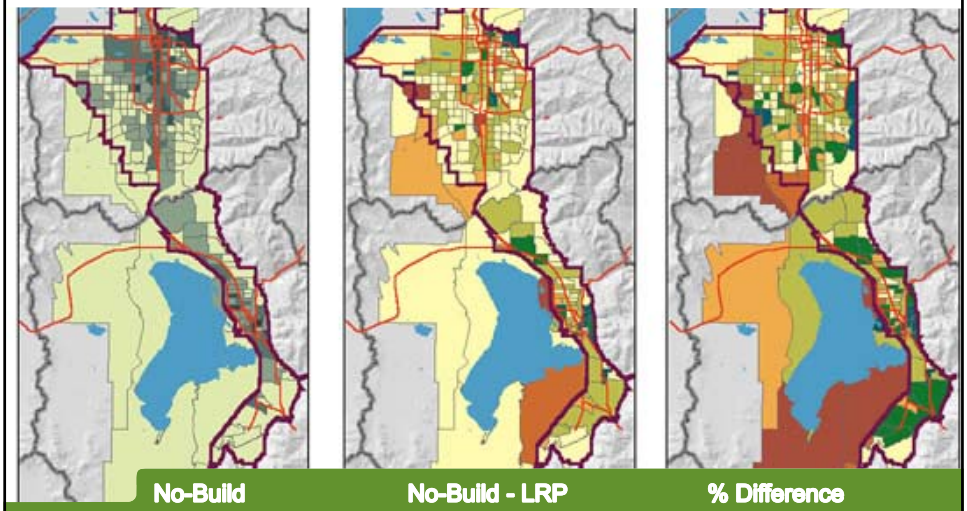
UGB Scenario
Access to Employment



UGB Scenario
Population



UGB Scenario Employment

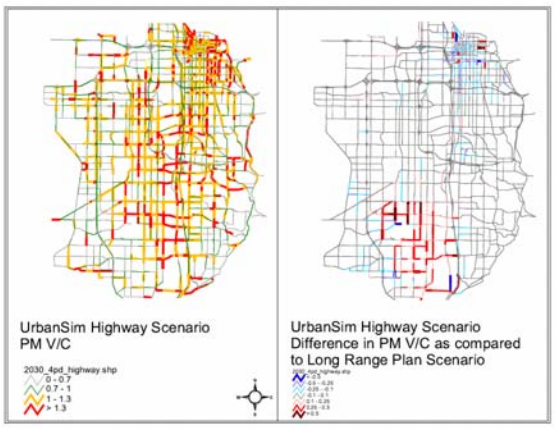


No-Build | No-Build - LRP | % Difference

Model Results

“REMOVE A HIGHWAY”

Omit Highway Scenario
Roadway Volume-to-Capacity Ratio



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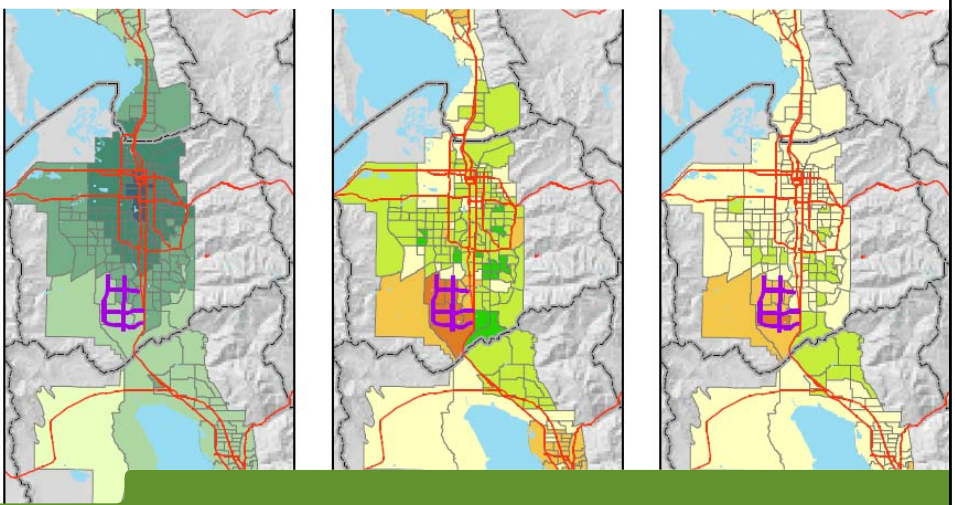
Omit Highway Scenario
Access to Employment



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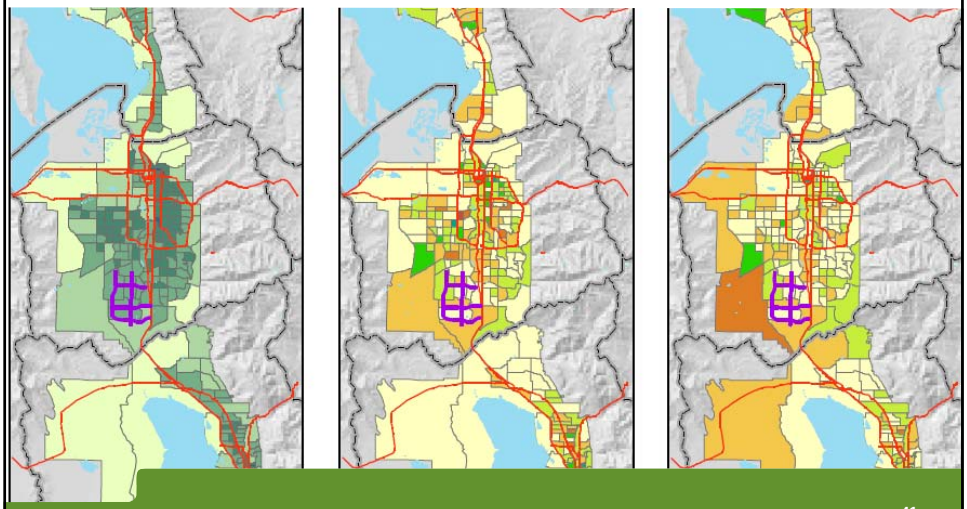
Omit Highway Scenario Population



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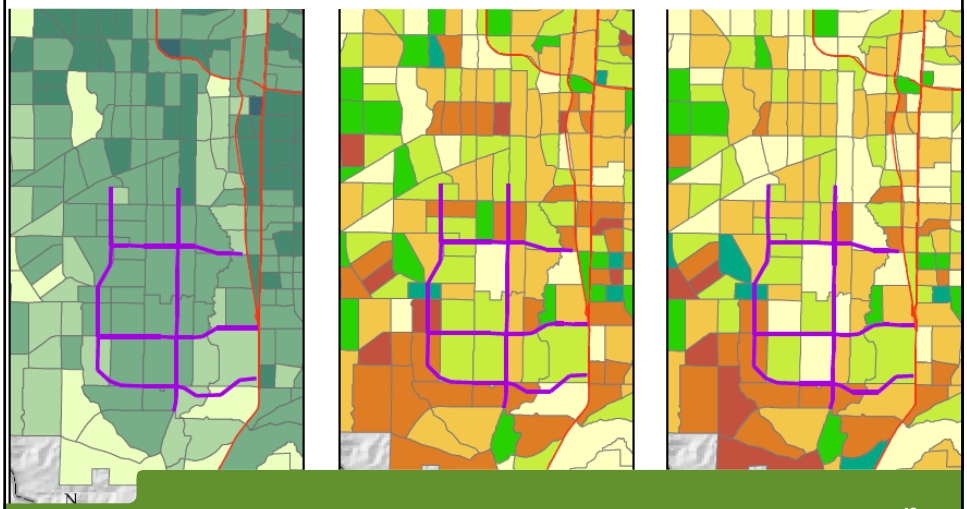
Omit Highway Scenario Population



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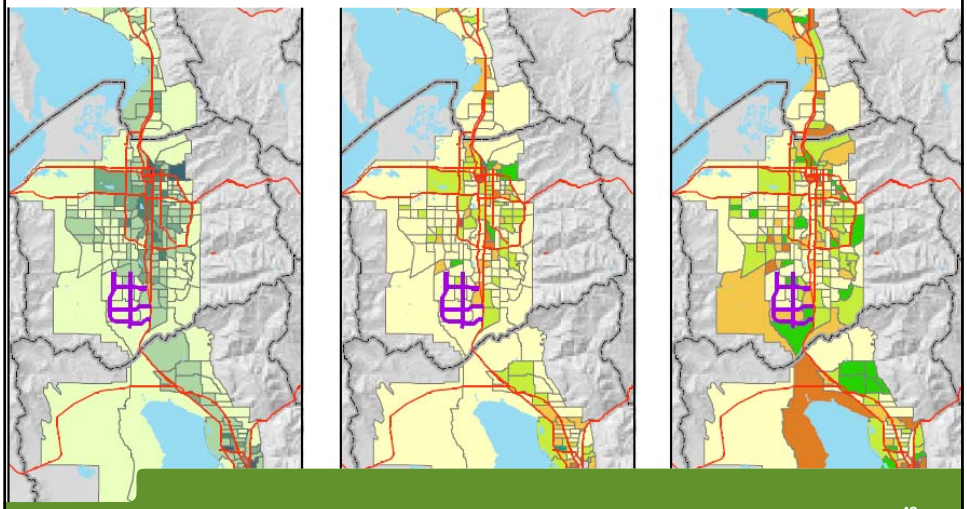
Omit Highway Scenario Employment



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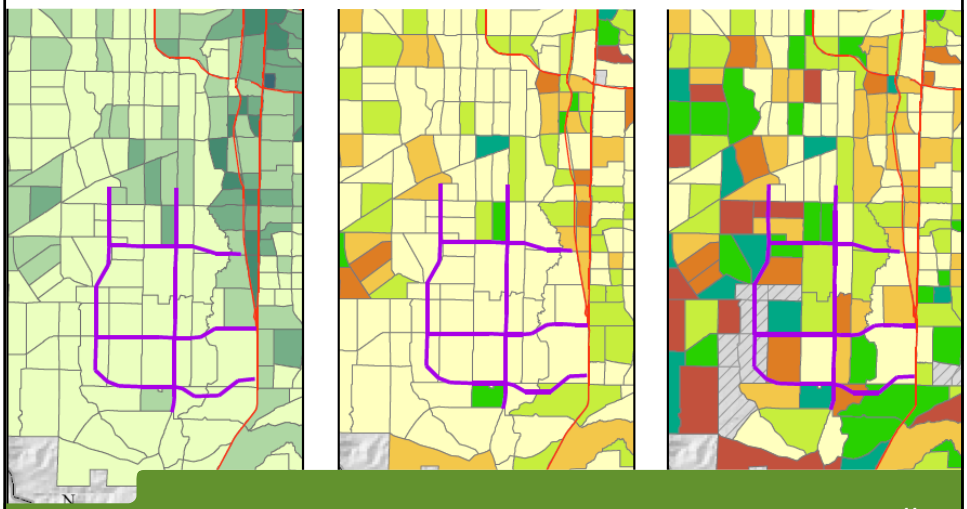
Omit Highway Scenario Employment



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Summary across Scenarios

Scenario	VMT[a] (000 s)	VHT[b] (000 s)	TCD[c] (000 s)	Transit share[d]
Base (1997)	39,403	1,095	110	2.38%
Adopted 2030 forecast	71,185	2,032	258	4.30%
Scenarios modeled with UrbanSim				
LRP[e]	75,058	2,143	298	4.26%
No-build	67,307	2,800	1,061	1.92%
Highway	74,500	2,127	291	4.24%
Transit	75,184	2,154	303	4.07%
Parking	74,797	2,132	295	4.44%
UGB[f]	72,580	2,094	289	4.47%
Comparison to adopted 2030 forecast				
UrbanSim LRP	+5.44%	+5.44%	+15.54%	−0.04%
Comparison to UrbanSim LRP scenario				
No-build	−10.3%	+30.7%	+256.4%	−2.3%
Highway	−0.7%	−0.7%	−2.3%	0.0%
Transit	+0.2%	+0.5%	+1.9%	−0.2%
Parking	−0.3%	−0.5%	−0.9%	+0.2%
UGB	−3.3%	−2.3%	−3.0%	+0.2%

[a] VMT is vehicle miles travelled.
[b] VHT is vehicle hours travelled.
[c] TCD is total hours of congestion delay.
[d] Transit share is the transit mode share for the home-based work trip purpose.
[e] LRP is the WFRC Long Range Plan.
[f] UGB is an urban growth boundary.

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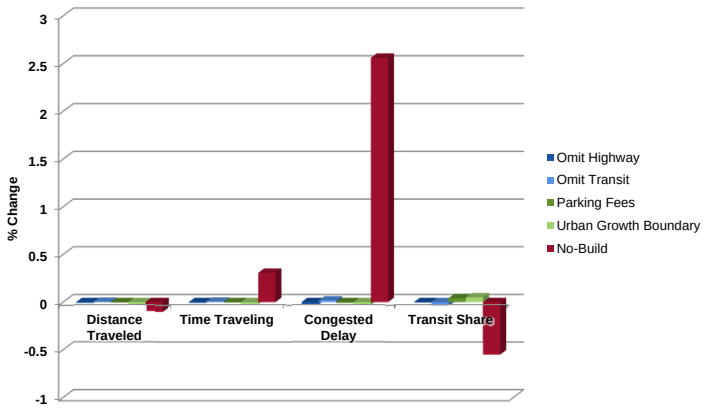
Comparison to Long Range Plan



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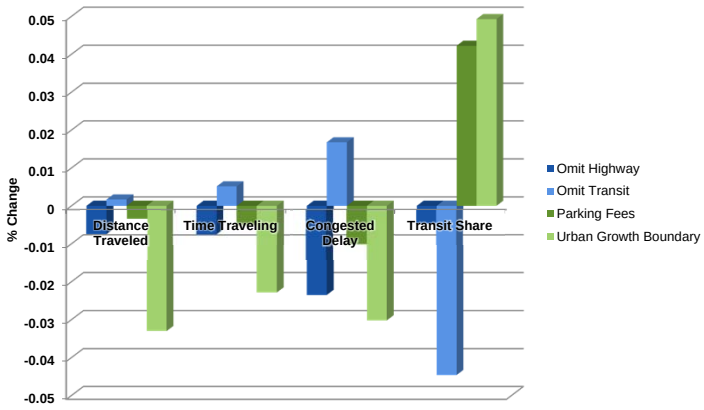
Comparison to Long Range Plan



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Key Findings from Peer Review

UrbanSim seemed to provide realistic results for policy tests, both on land use and transport, at *aggregate* level

Sensitivity of land use to new transport infrastructure was *very low!*

Panel recommended using UrbanSim for regional analysis, but *not* for corridor analysis

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Rest of the Story: 2004—2006

Regional Government incorporates UrbanSim into planning processes

- Data Problems
- Processing Problems
- Staff Turnover

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Rest of the Story: 2004—2006

Revised Environmental Impact Statement

- Proceeds **without** using UrbanSim
- Only a subjective assessment of induced growth

Conditions for Redesign (valid until 2020):

- No Billboards
- No Trucks
- Speed Limit: 90 km/h

Revised EIS is approved

Construction Resumes

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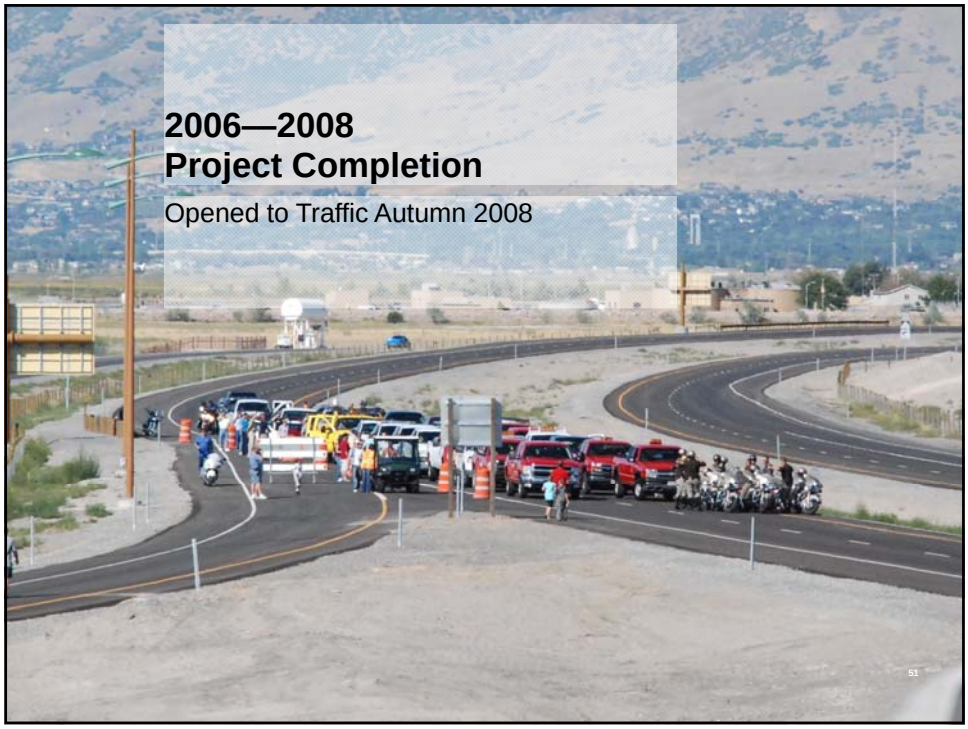
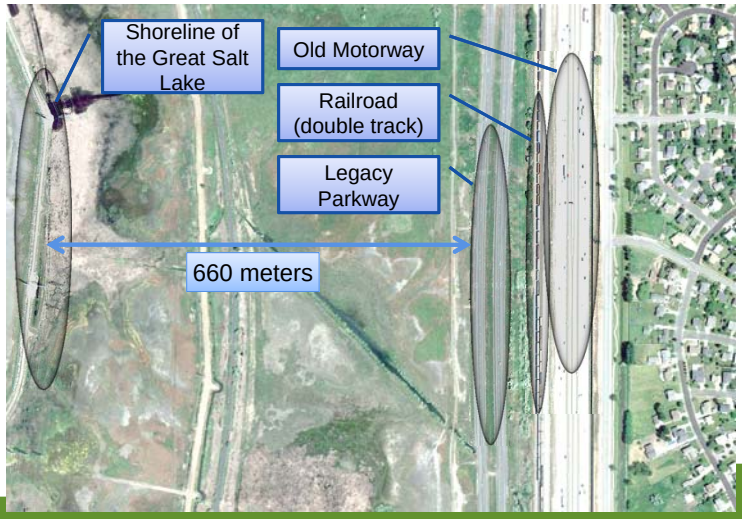


Legacy Parkway Today



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The Metropolitan Council Today

WFRC's Reflections:

- "UrbanSim…requires a dedicated, trained, medium-to-high level programming and modeler resource" (2 individuals for 2 years).
- Each modeling run of UrbanSim took a week or more of programming and data preparation.
  - UrbanSim model was 72 continuous hours
  - Travel model runs took several hours to a day to run.
- This level of resource commitment and modeling time was acceptable, but did not allow for numerous runs or adjustments to the model.

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The Metropolitan Council Today

WFRC's Reflections (continued):

- UrbanSim…was a unique feature that allowed consideration of land use principles before determination of transportation needs.
- Some resistance to the use of UrbanSim as a tool to model population and employment demographics
  - Due to the granularity of the analysis - 150 meter grid
  - And it took additional time.
- Stayed with the 150 meter grid
  - Could be used for detailed work when required

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Questions for Reflection

Was the construction of the Legacy Parkway the **right thing to do**?

What went wrong with the implementation of UrbanSim?

Can Long Range Planning **rely** on complex urban models?

Should **legal settlements** rely on complex urban models?