

# Urban Metabolism

## Understanding Resource Flows in Cities



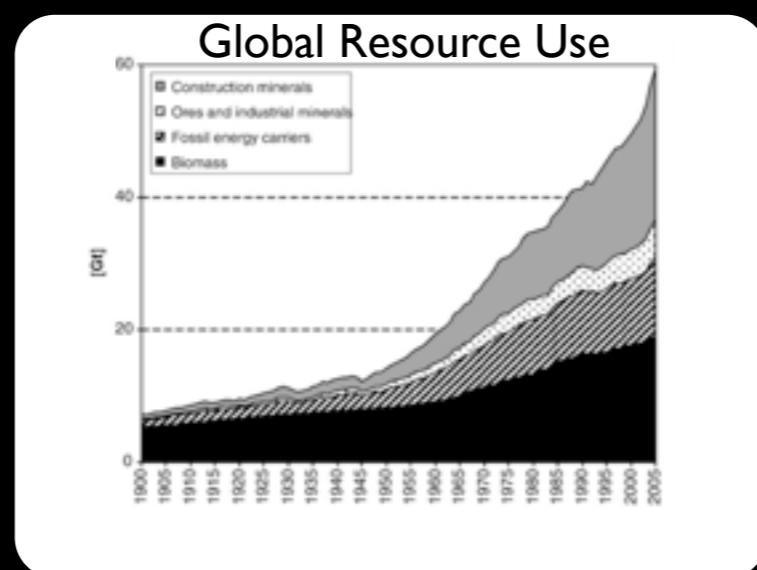
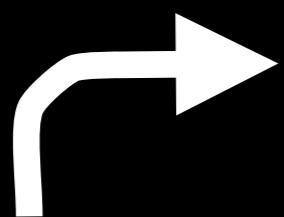
David Quinn - PhD Student  
John E. Fernández - Adviser

Source: <http://earthobservatory.nasa.gov/IOTD/view.php?id=896>

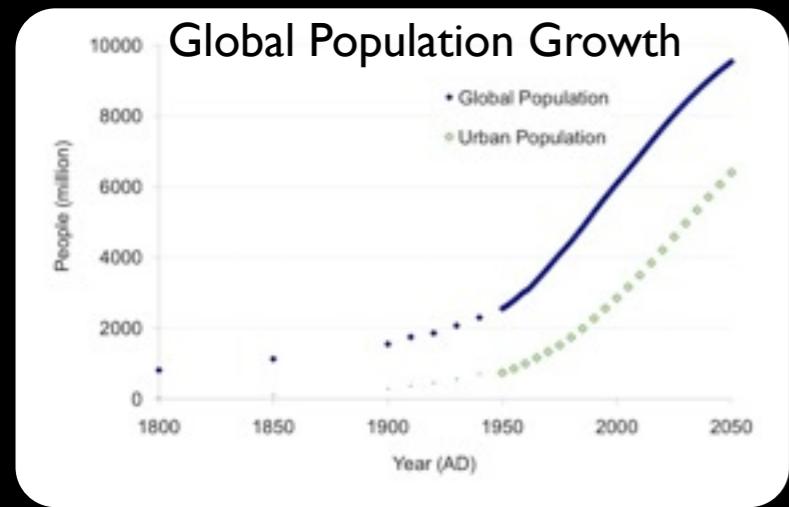
# Research Presentation

- I. Research Motivation**
- 2. Research Process**
- 3. Provisional Results**
- 4. Future Direction**

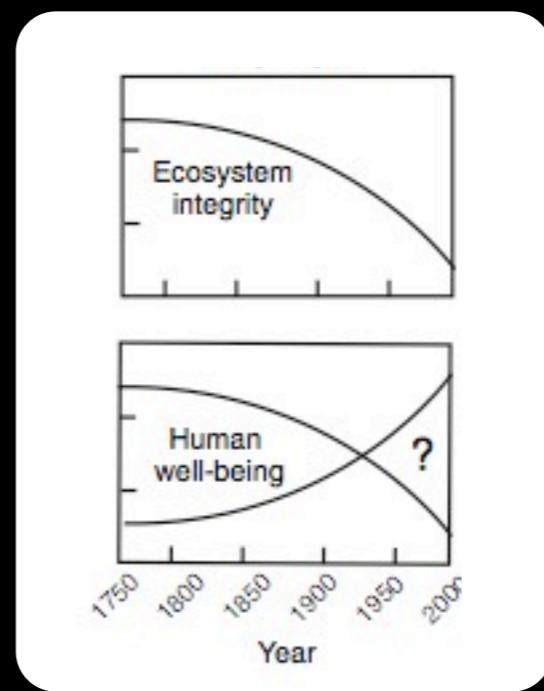
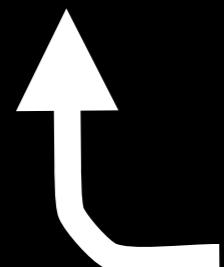
# Global Dynamics



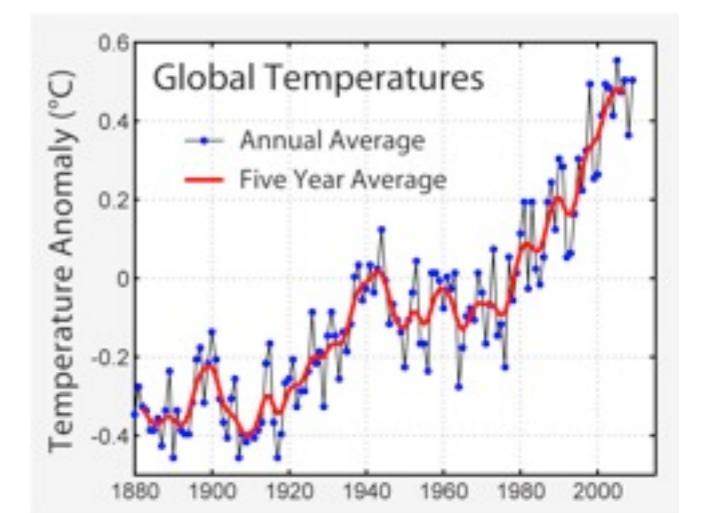
Source: Krausmann (2009)



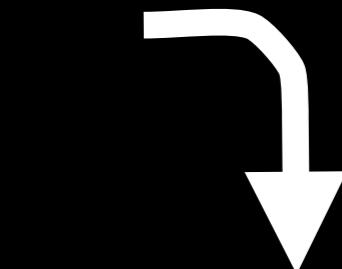
Data:  
US Census  
UN Population  
Projection



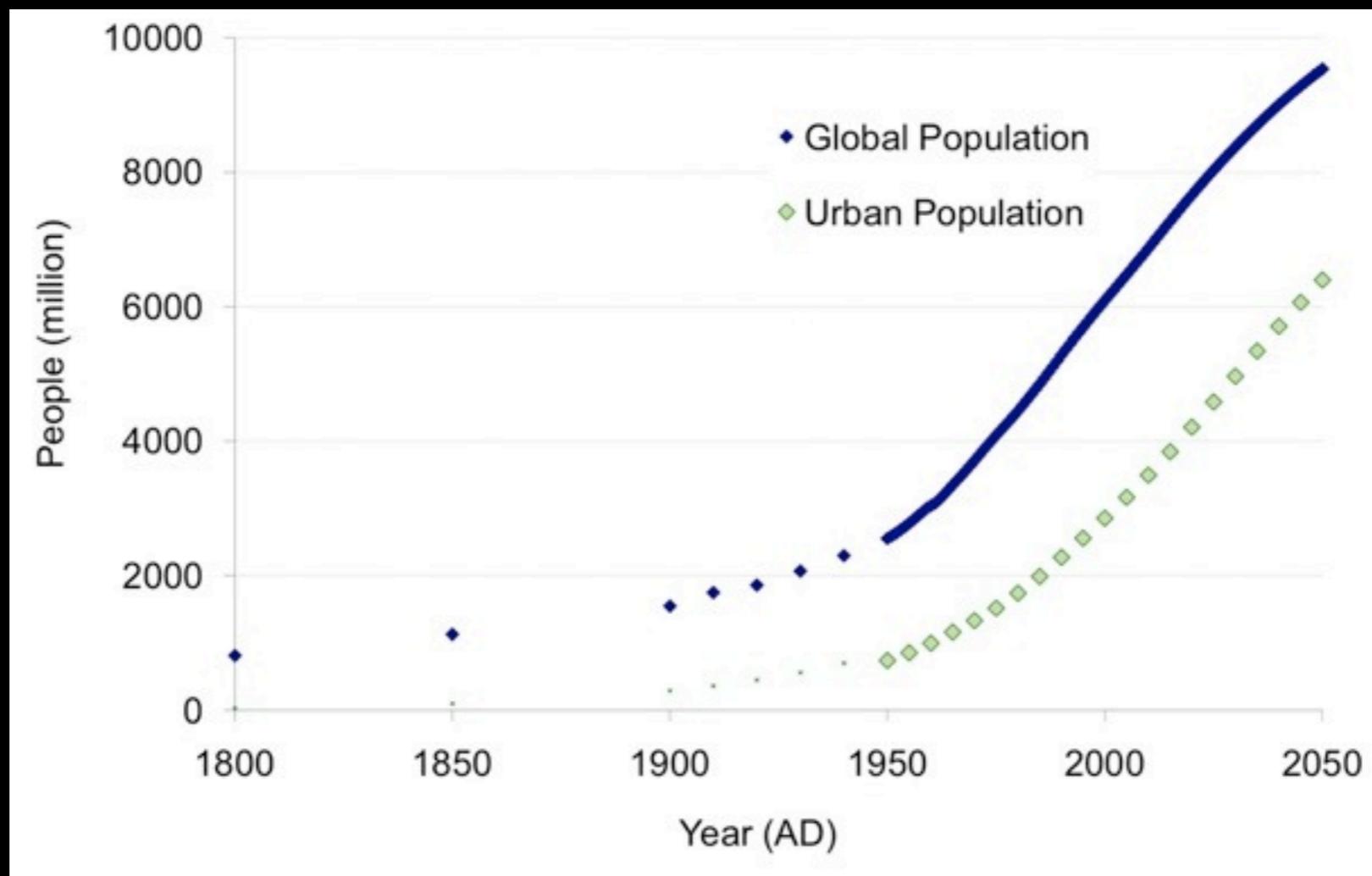
Source:  
Folke (2009)



Source:  
NASA (2007)

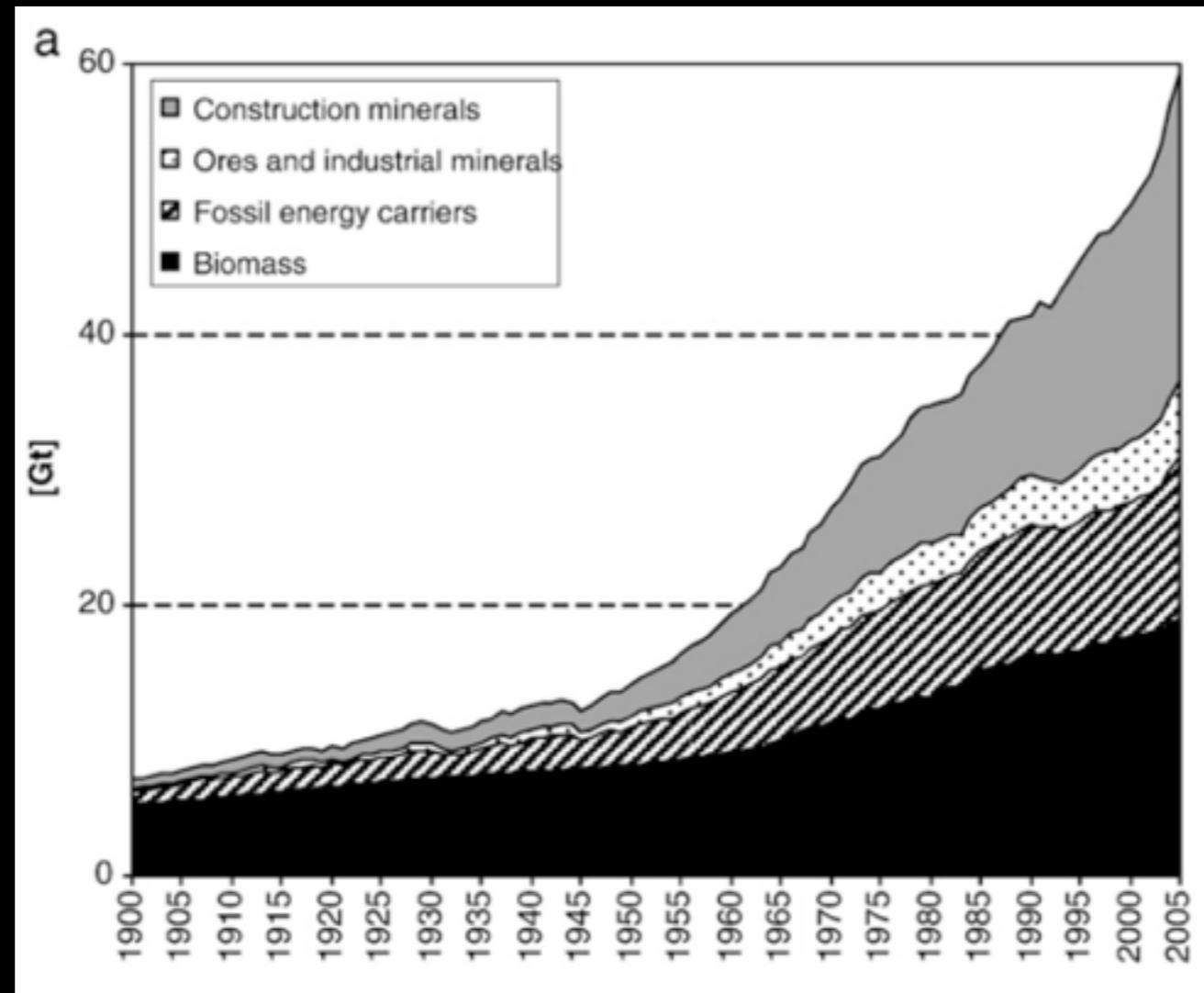


# Global Dynamics



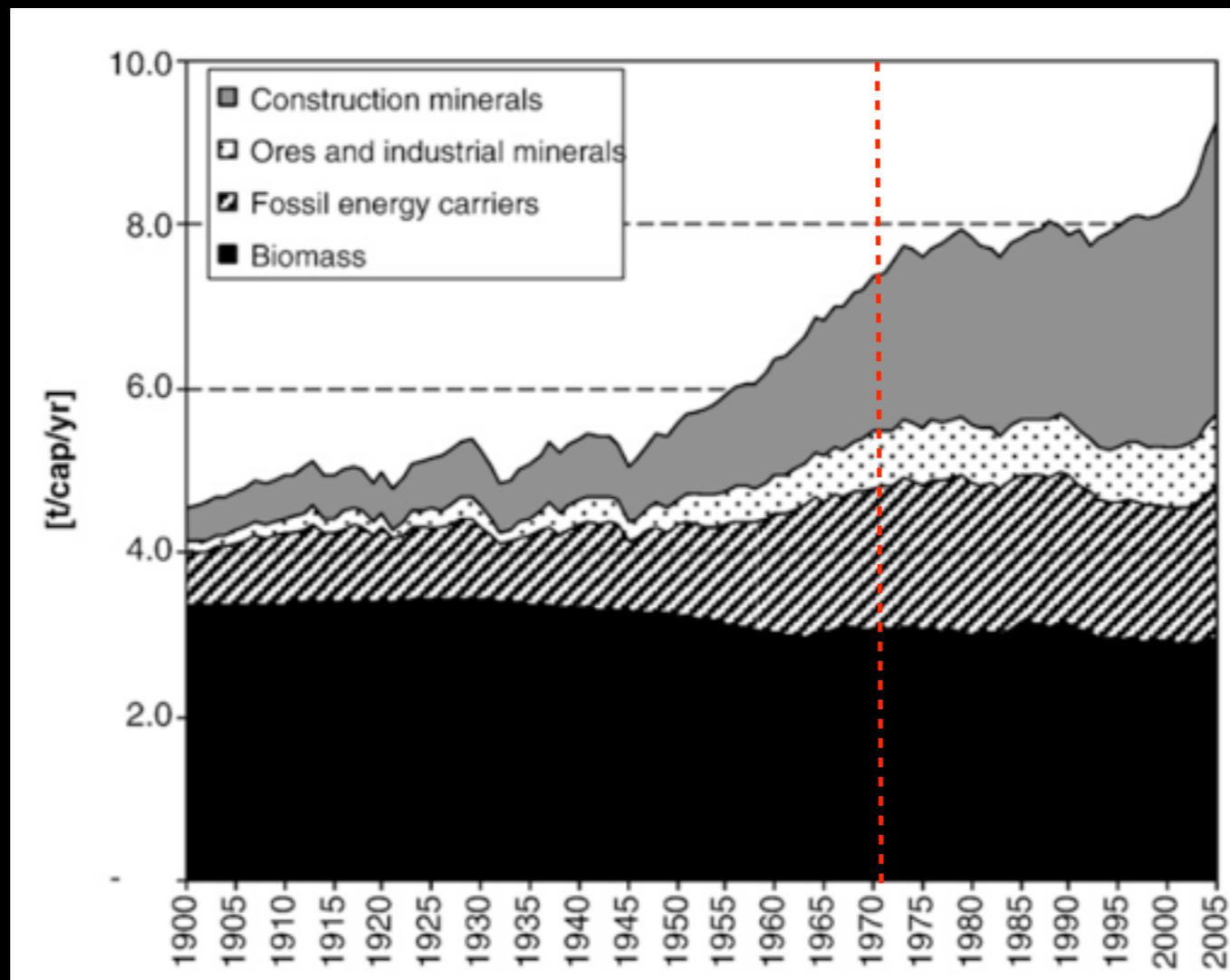
Data:  
US Census  
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# Global Dynamics



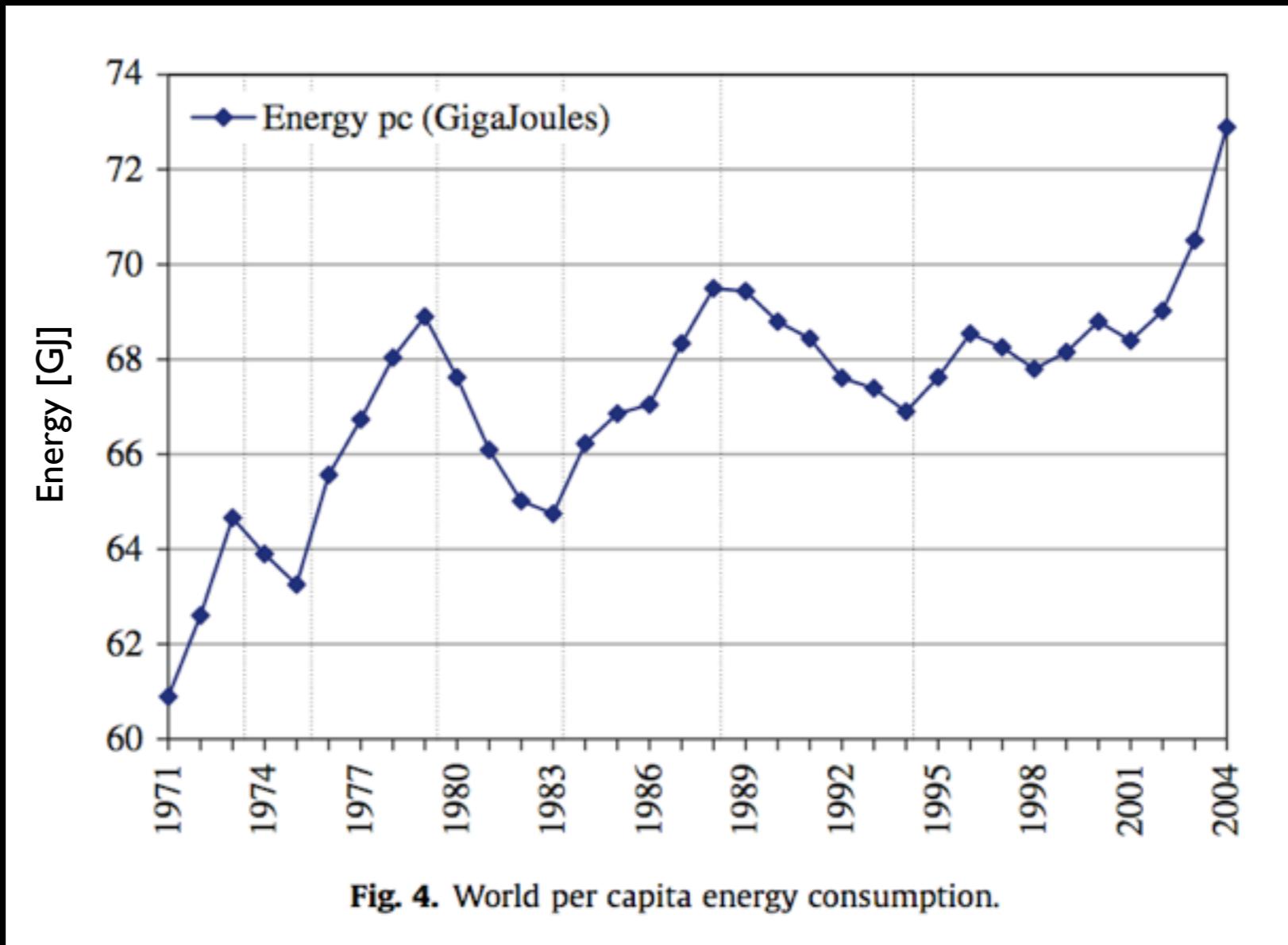
Source:  
Krausmann (2009)

# Individual Resource Use



Source:  
Krausmann (2009)

# Individual Energy Use

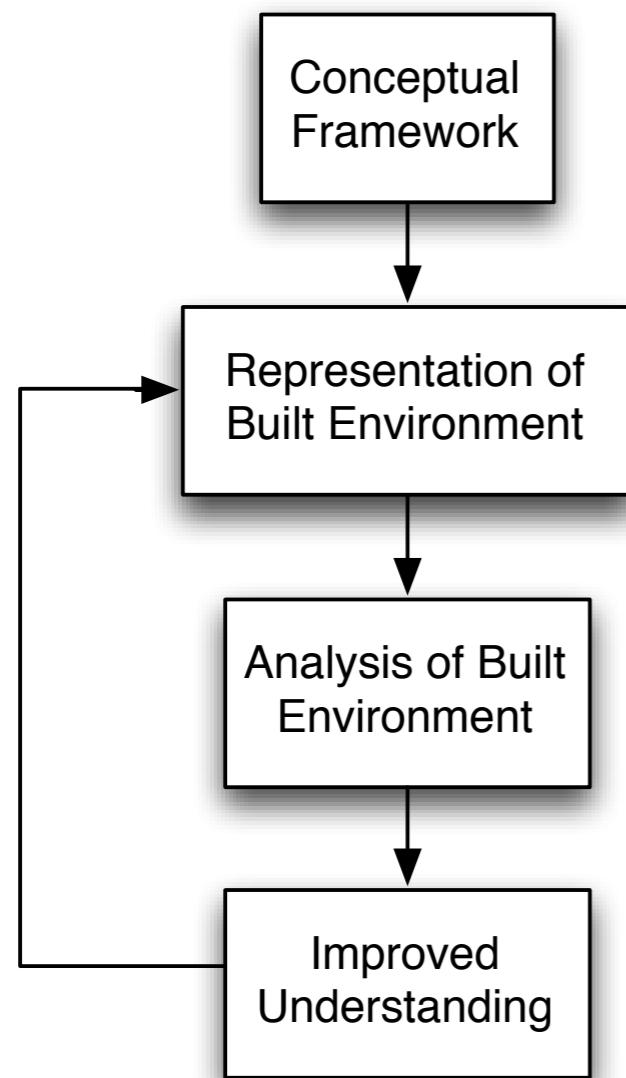


Source:  
Luzatti (2009)

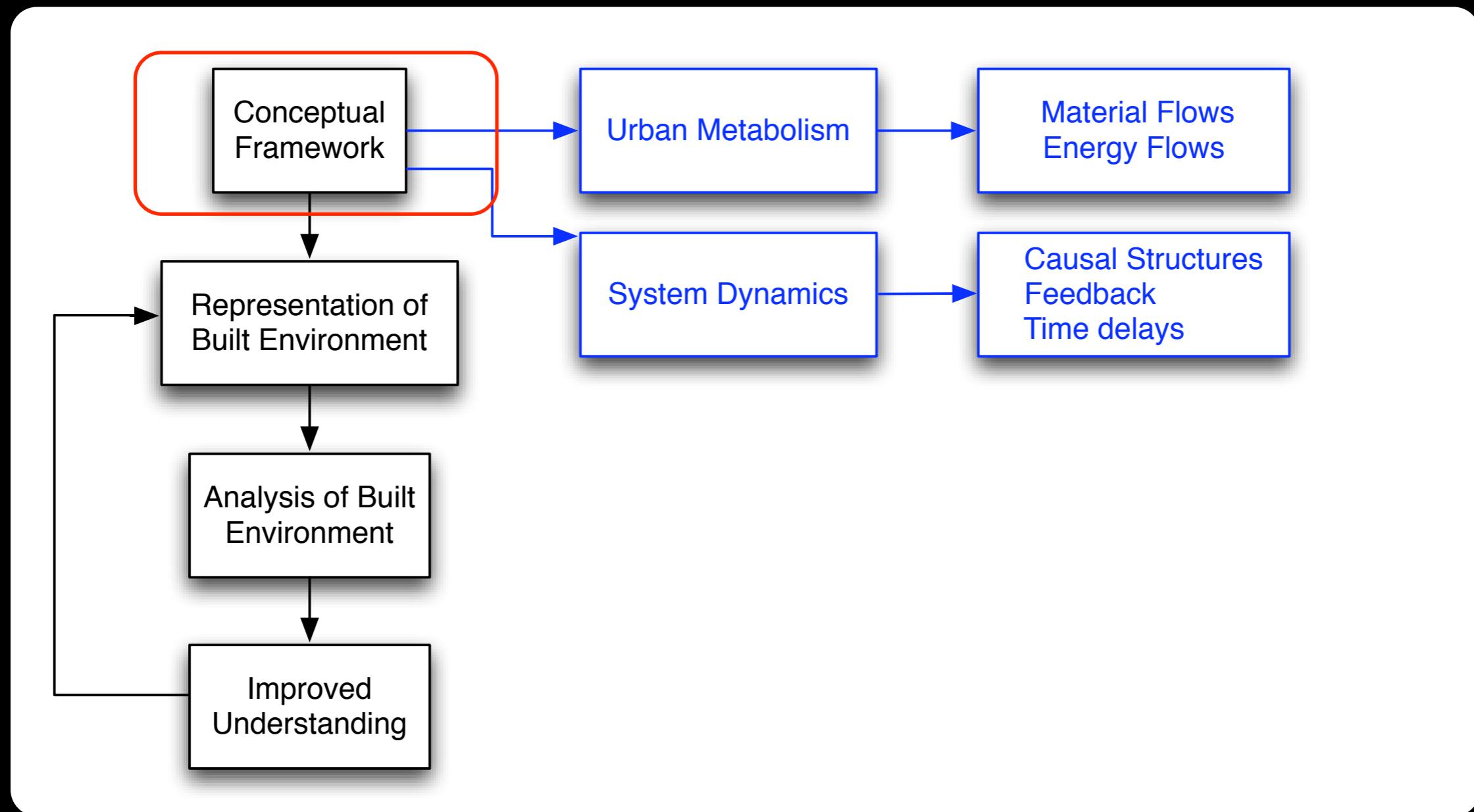
# Research Objective

Develop and validate a method for  
analyzing resource consumption of  
residential urban areas

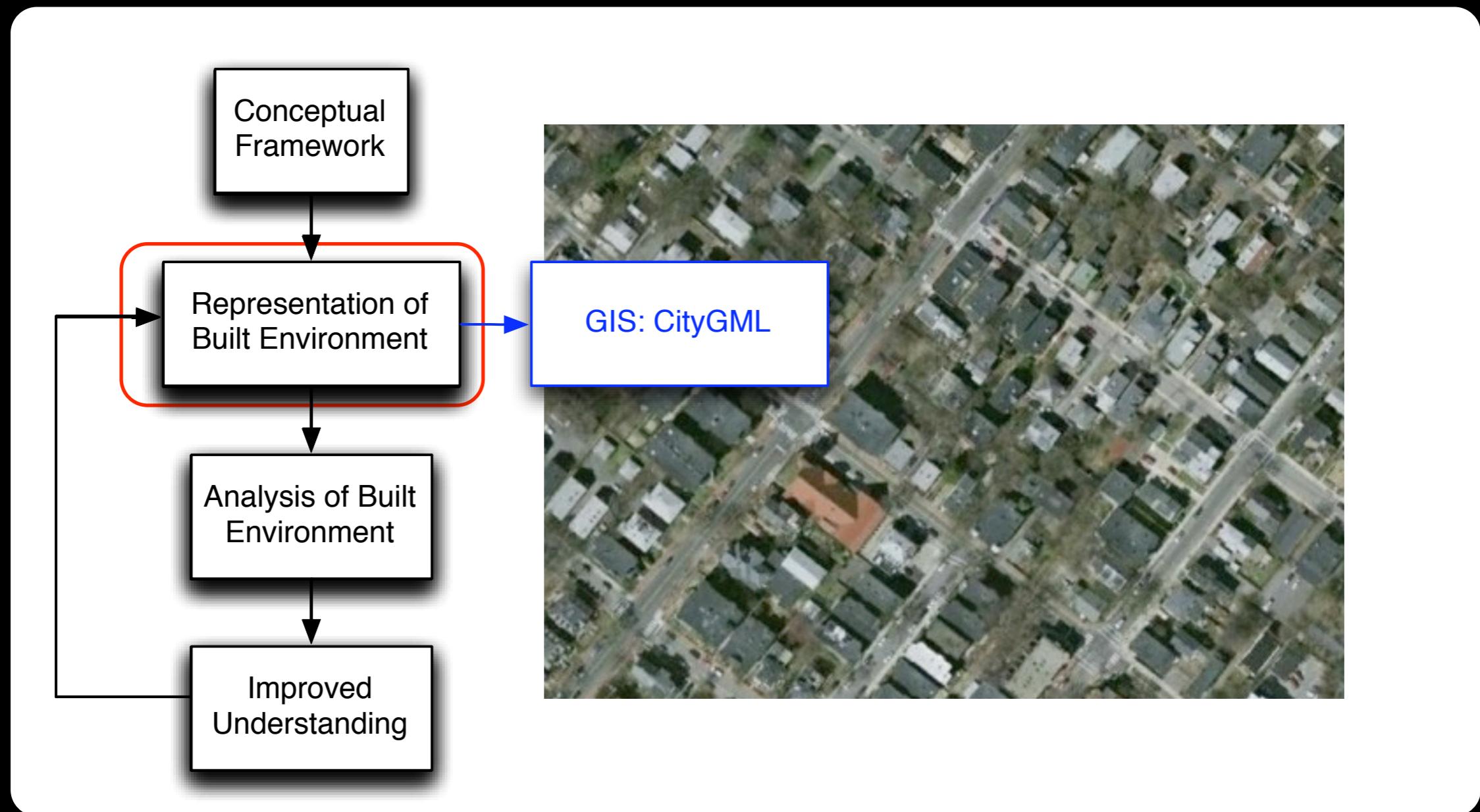
# Research Process



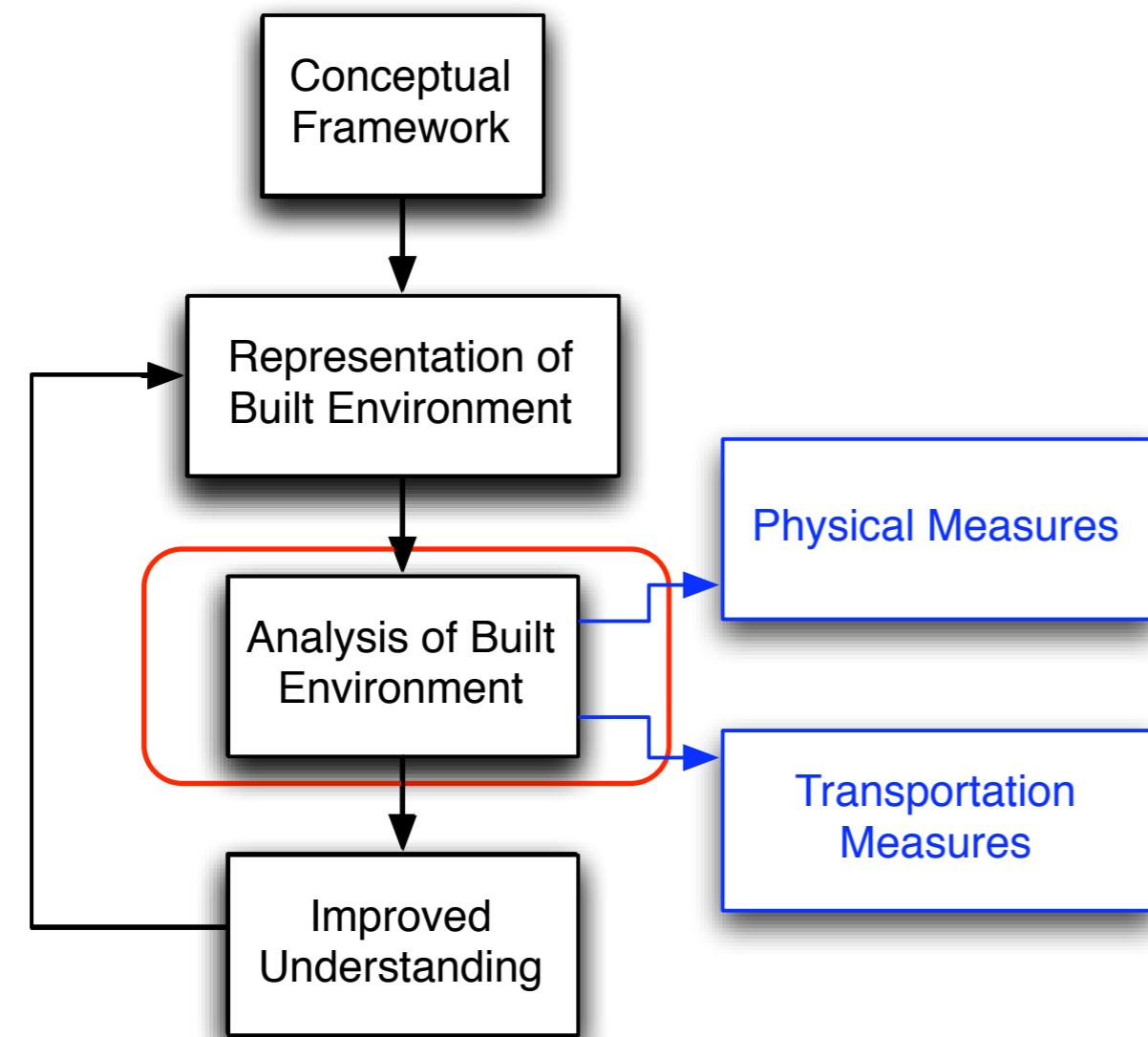
# Research Process



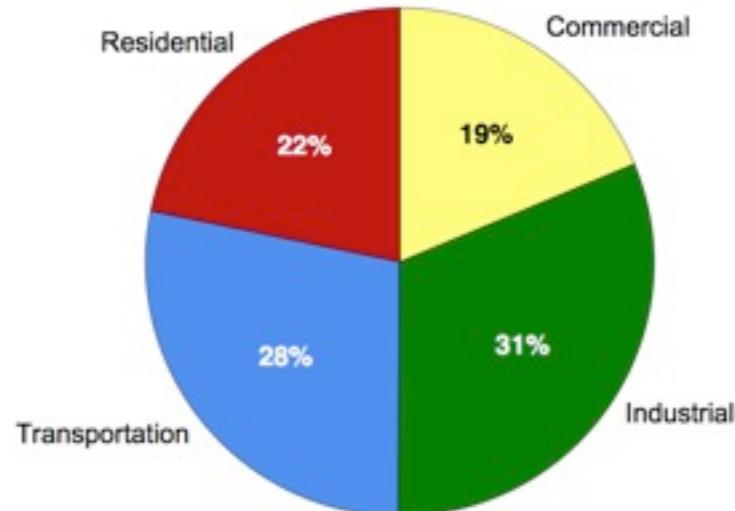
# Research Process



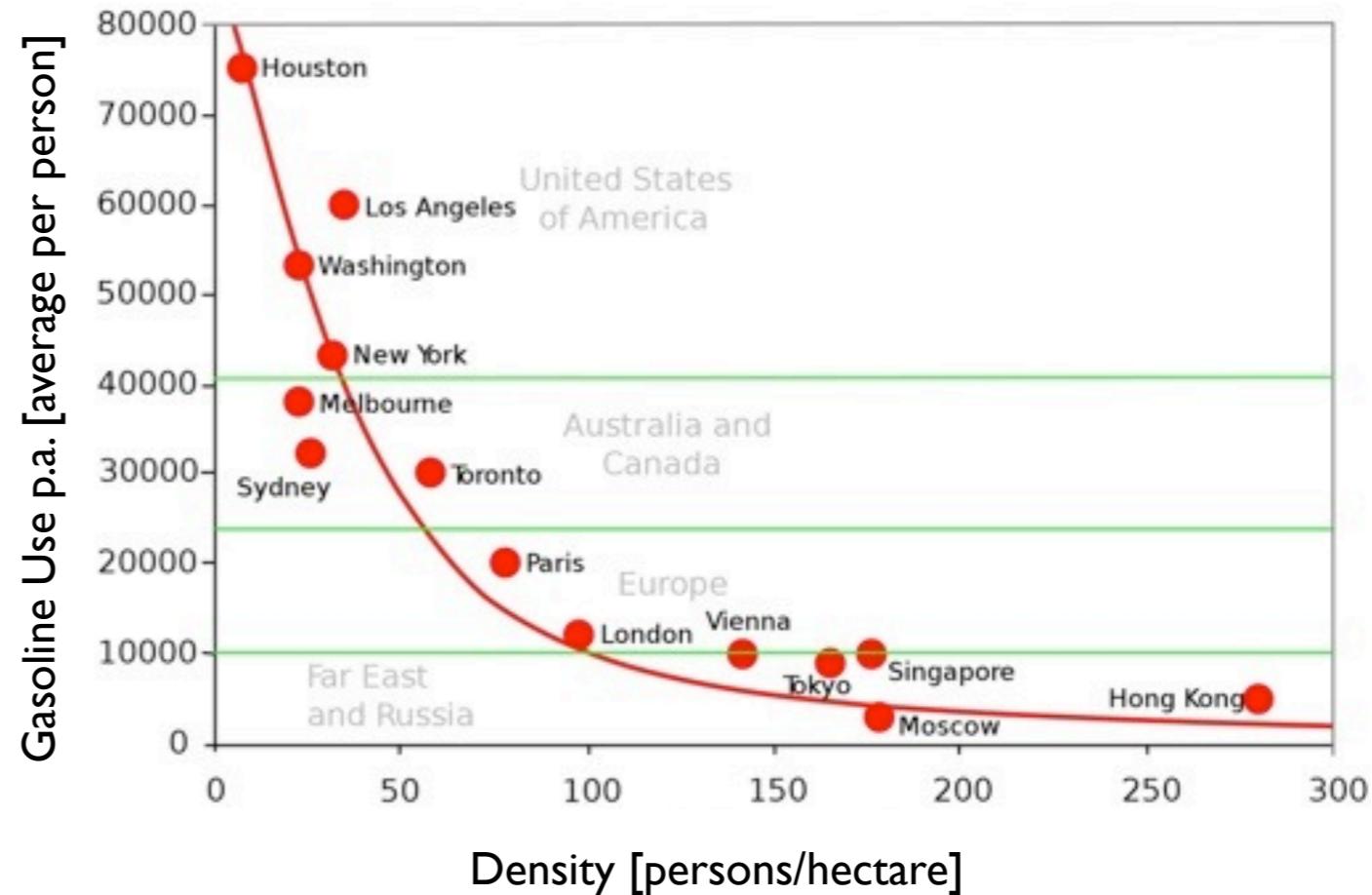
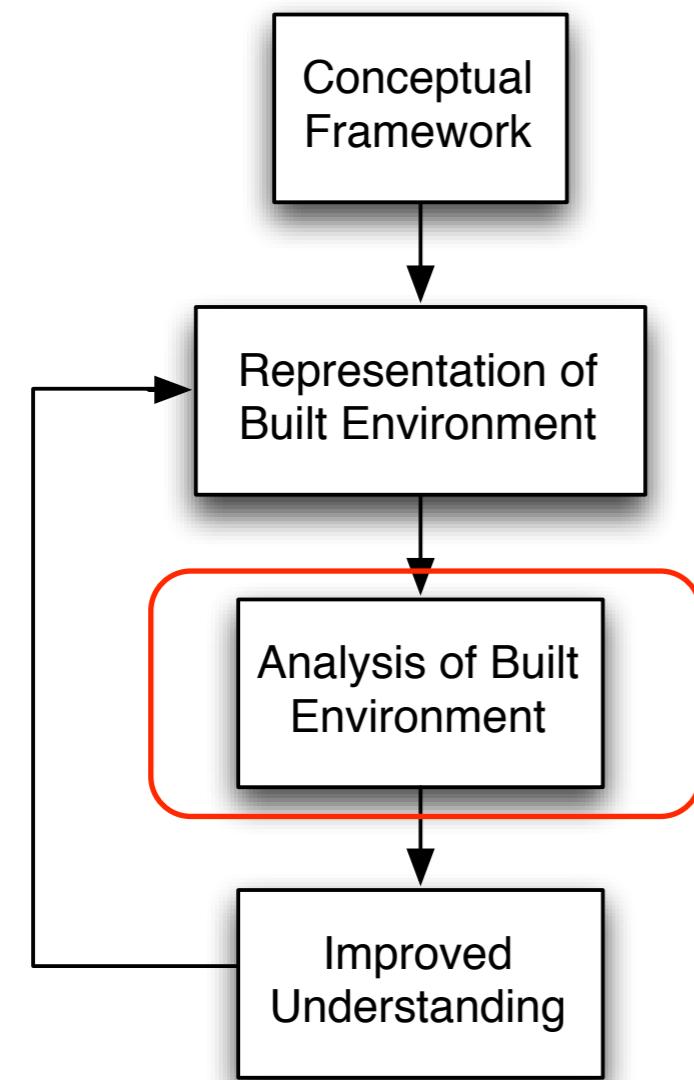
# Research Process



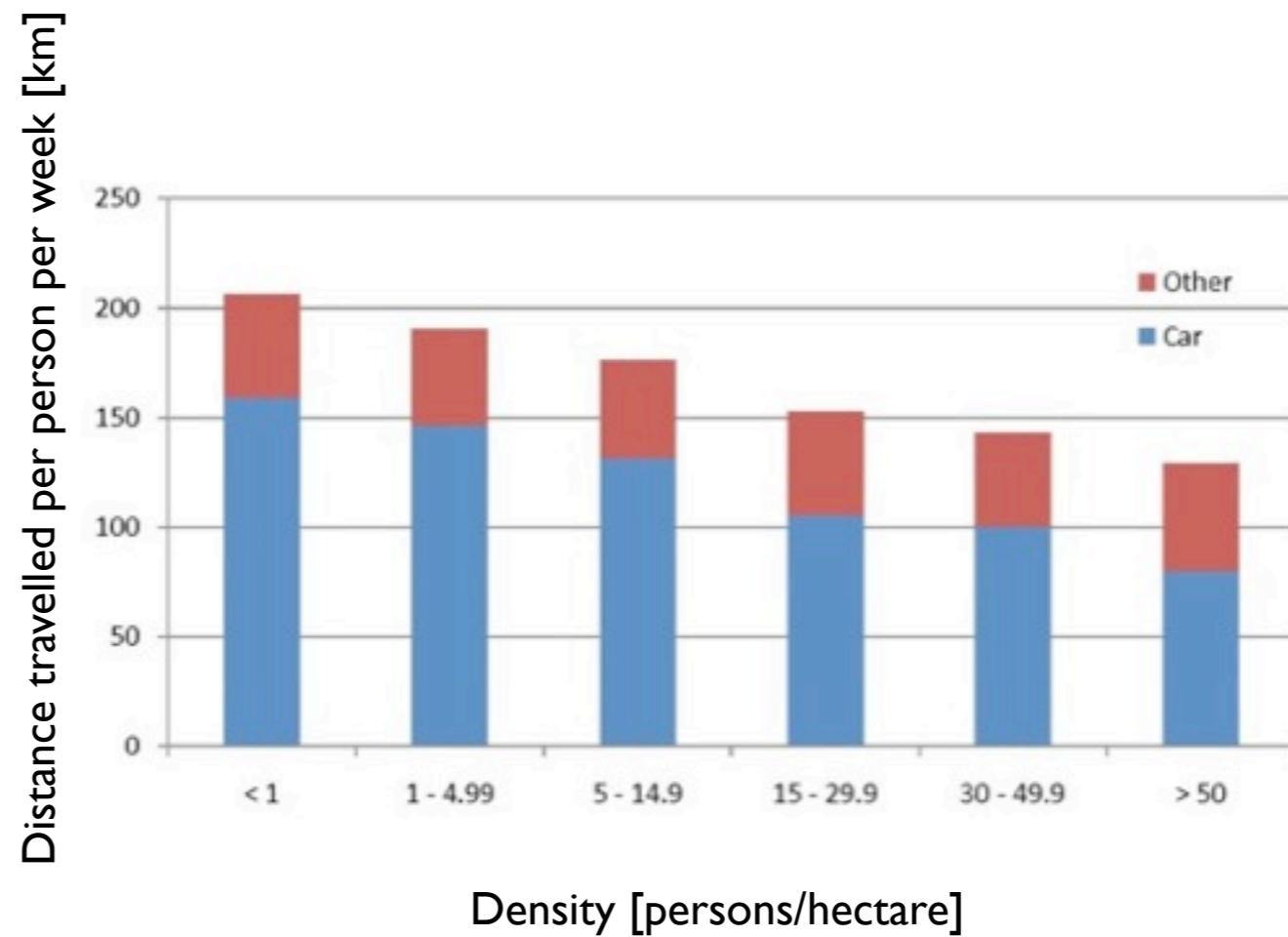
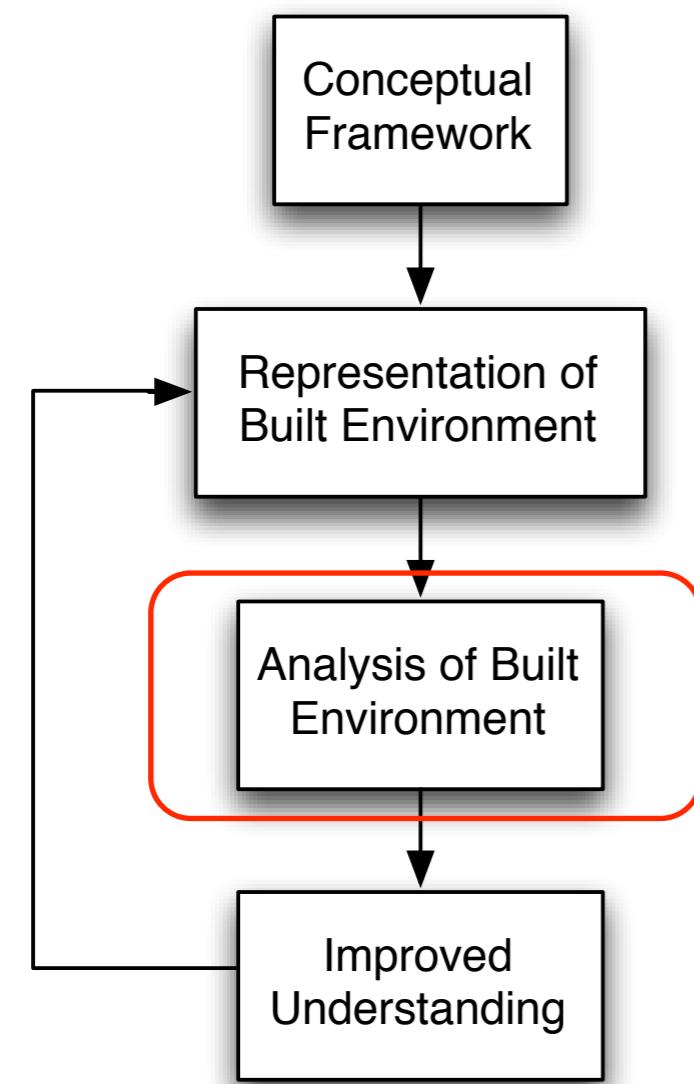
Energy Consumption by Sector



# Research Process



# Research Process



# Research Presentation

1. Research Motivation

2. Research Process

3. Provisional Results

3.1 Masters Research

3.2 PhD Research

4. Future Direction

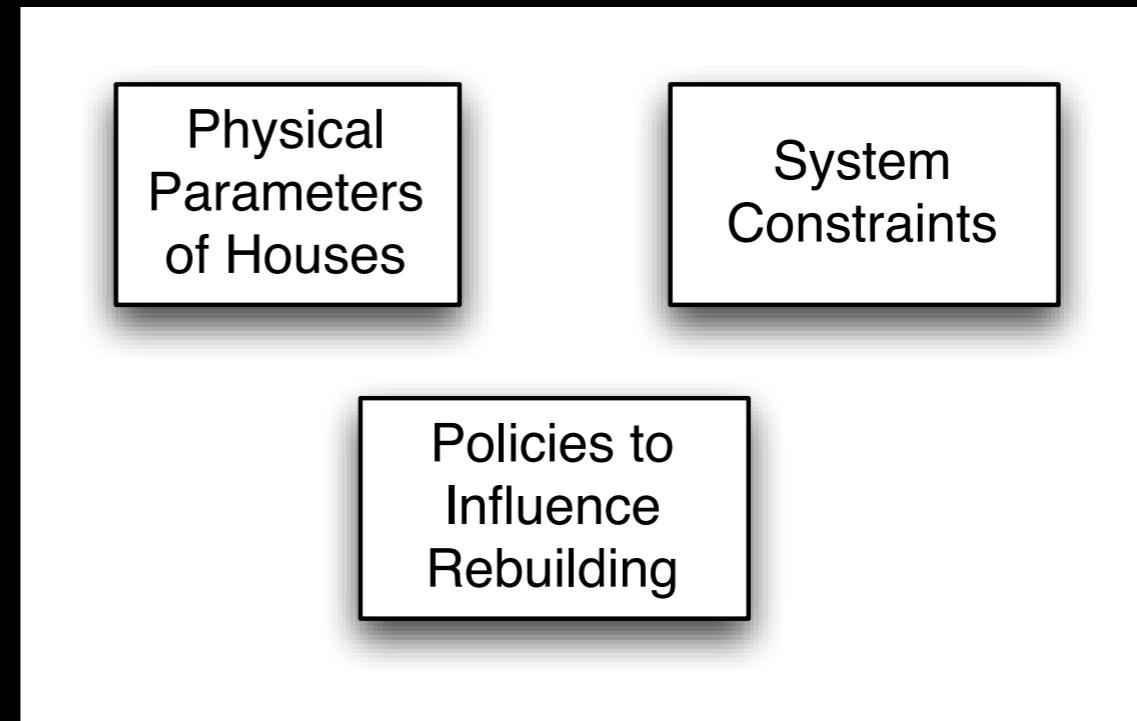
# Review of Research

- ▶ Masters Work: Housing reconstruction in New Orleans
- ▶ PhD Work: Analysis of urban form



3 Provisional Results

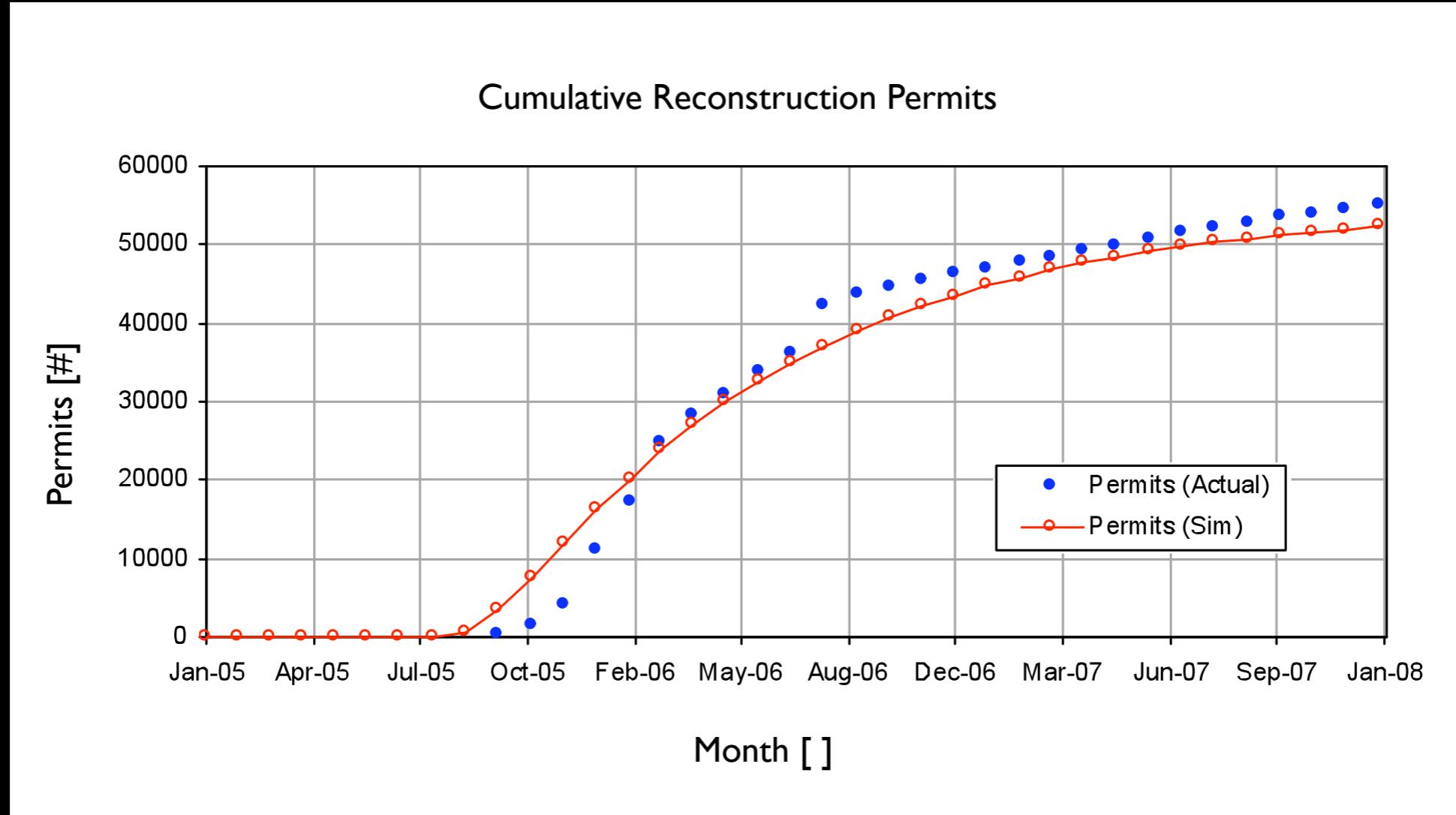
# Masters Research



## System Dynamics Model

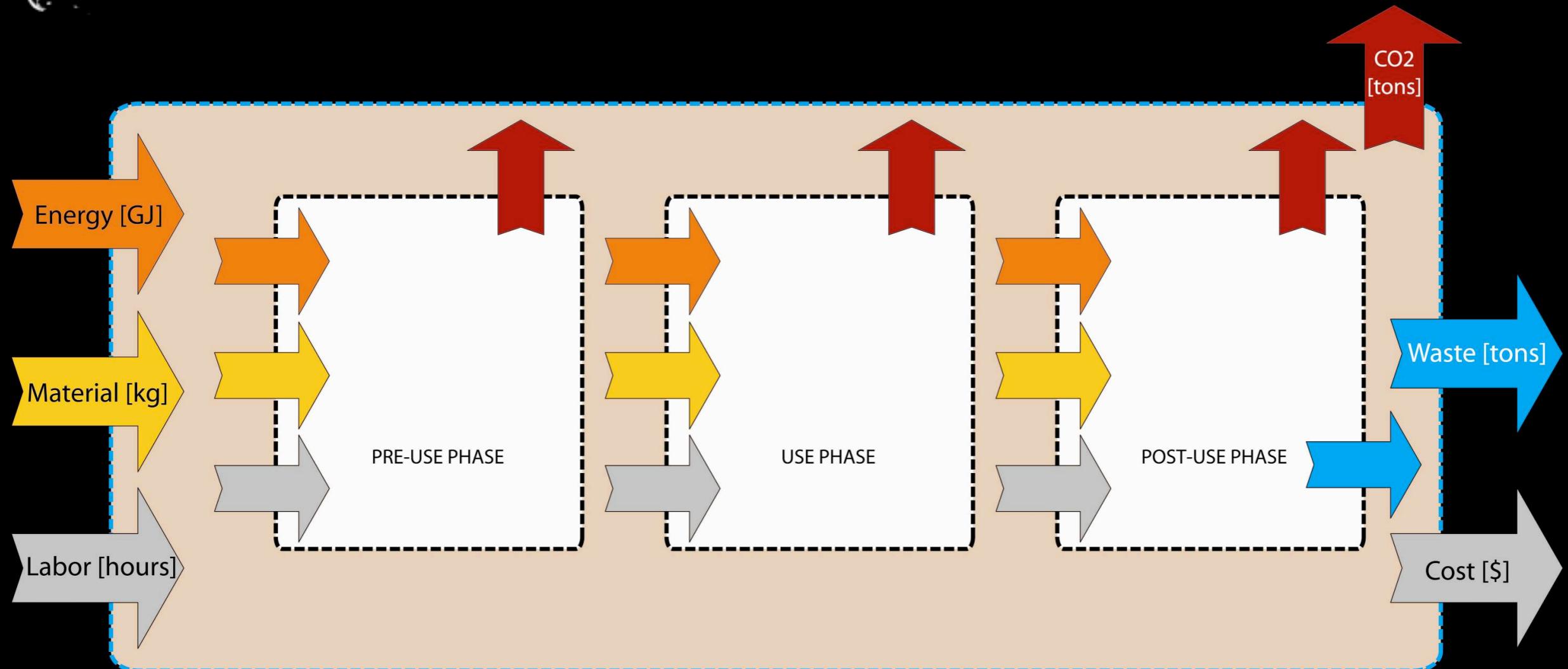


# Masters Research





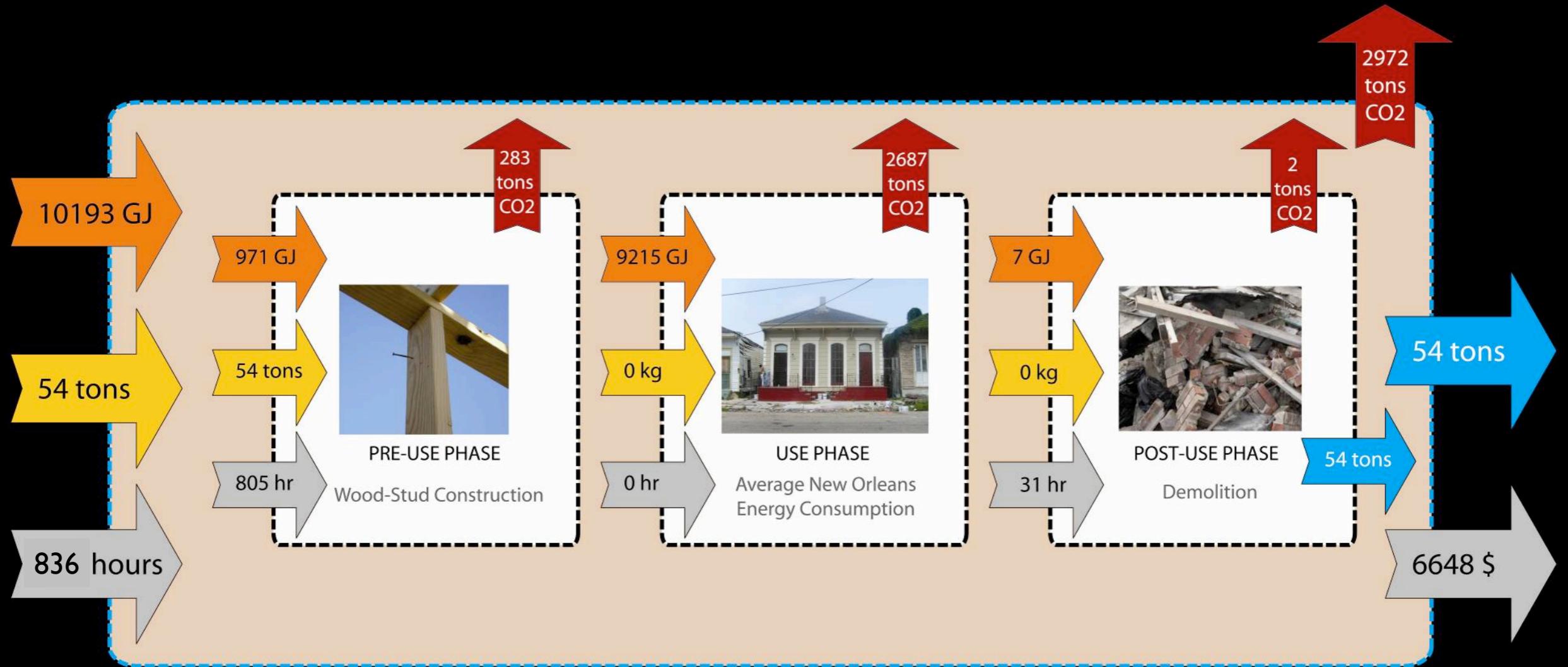
# Masters Research



Lifespan 75 years; House size 2000 sq ft



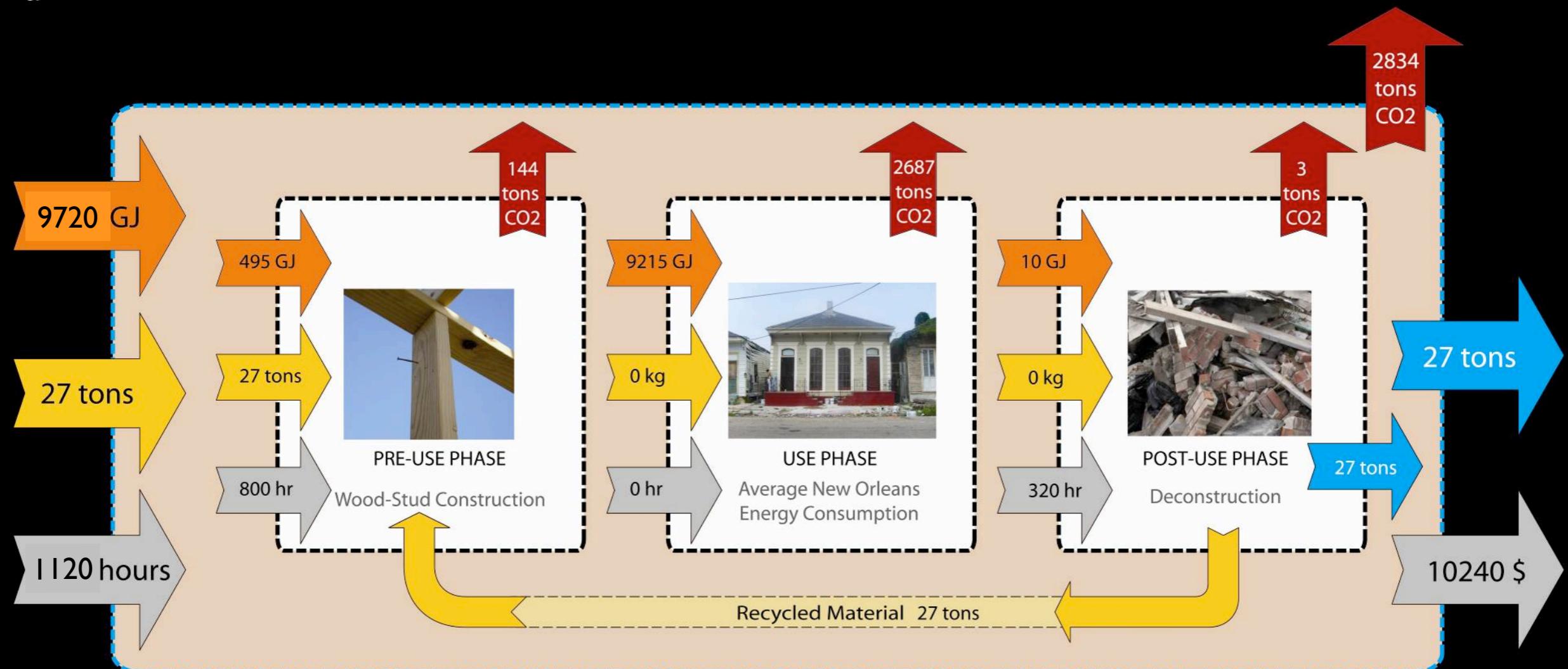
# Masters Research



Lifespan 75 years; House size 2000 sq ft



# Masters Research



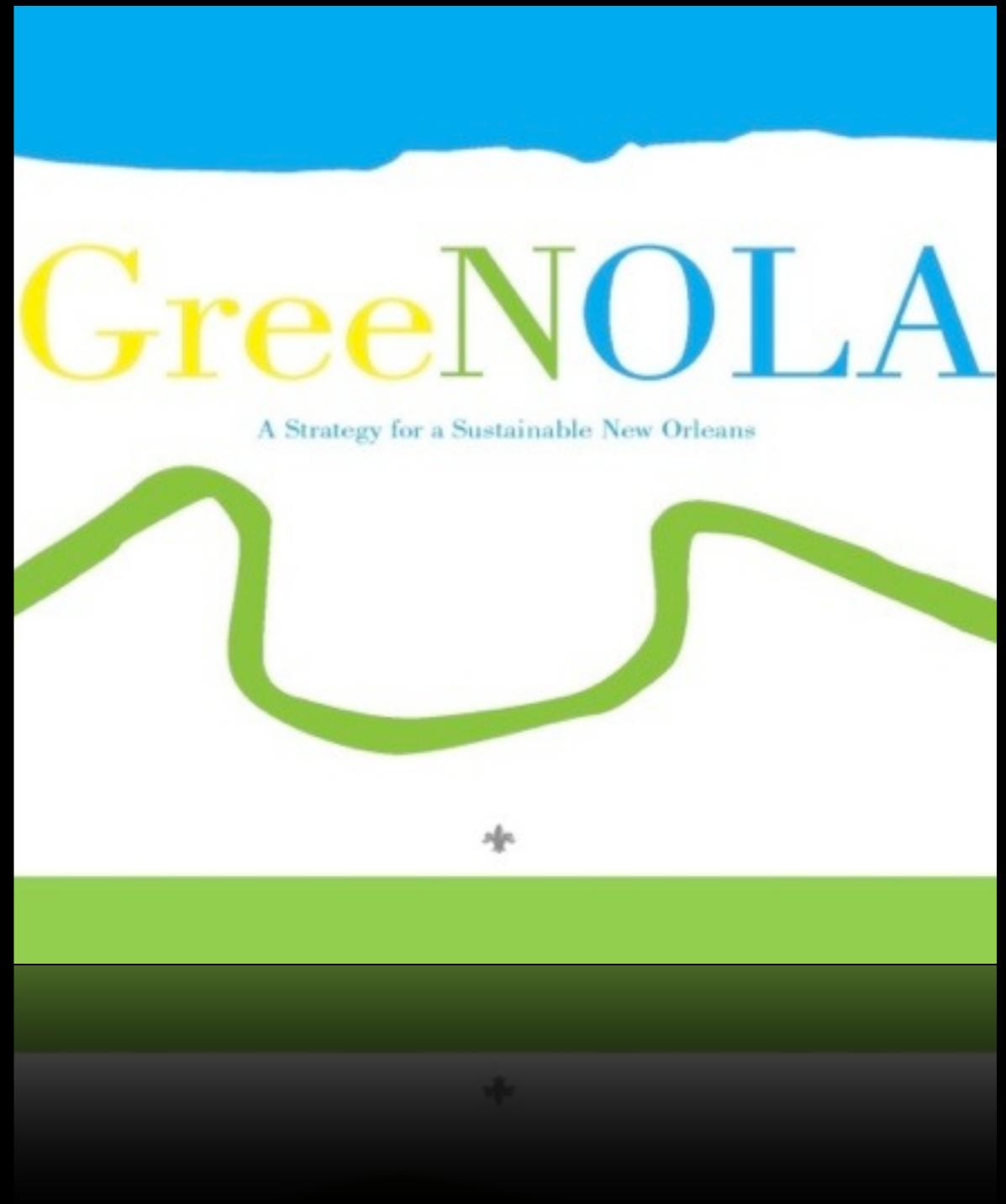
Lifespan 75 years; House size 2000 sq ft



# Masters Research

- Development of sustainability strategy for New Orleans
- Adopted by City Government (Fall '07)
- Funded by Clinton Climate Change (Jan '08 - \$1.6 million)

GreeNOLA Authors:  
Earthea Nance, Ph.D., P.E.,  
Wynecta Fisher,  
Jeffrey Schwartz,  
David Quinn



# PhD Research

# PhD Research



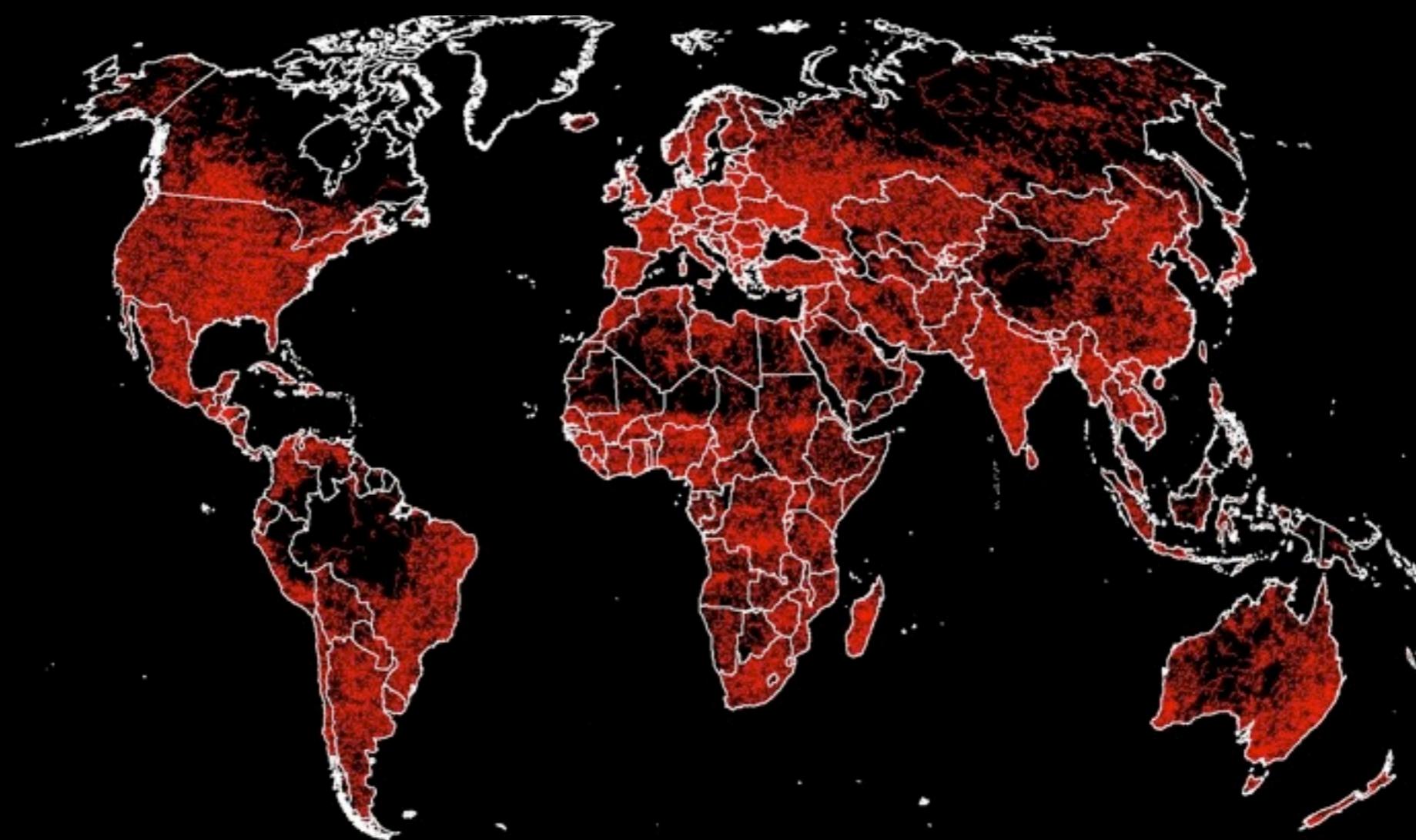
## Static Analysis:

- Global road patterns
- City scaling patterns and resource usage

## Dynamic Analysis

- Regional land-use change
- Urban growth modeling

# Global Road Patterns

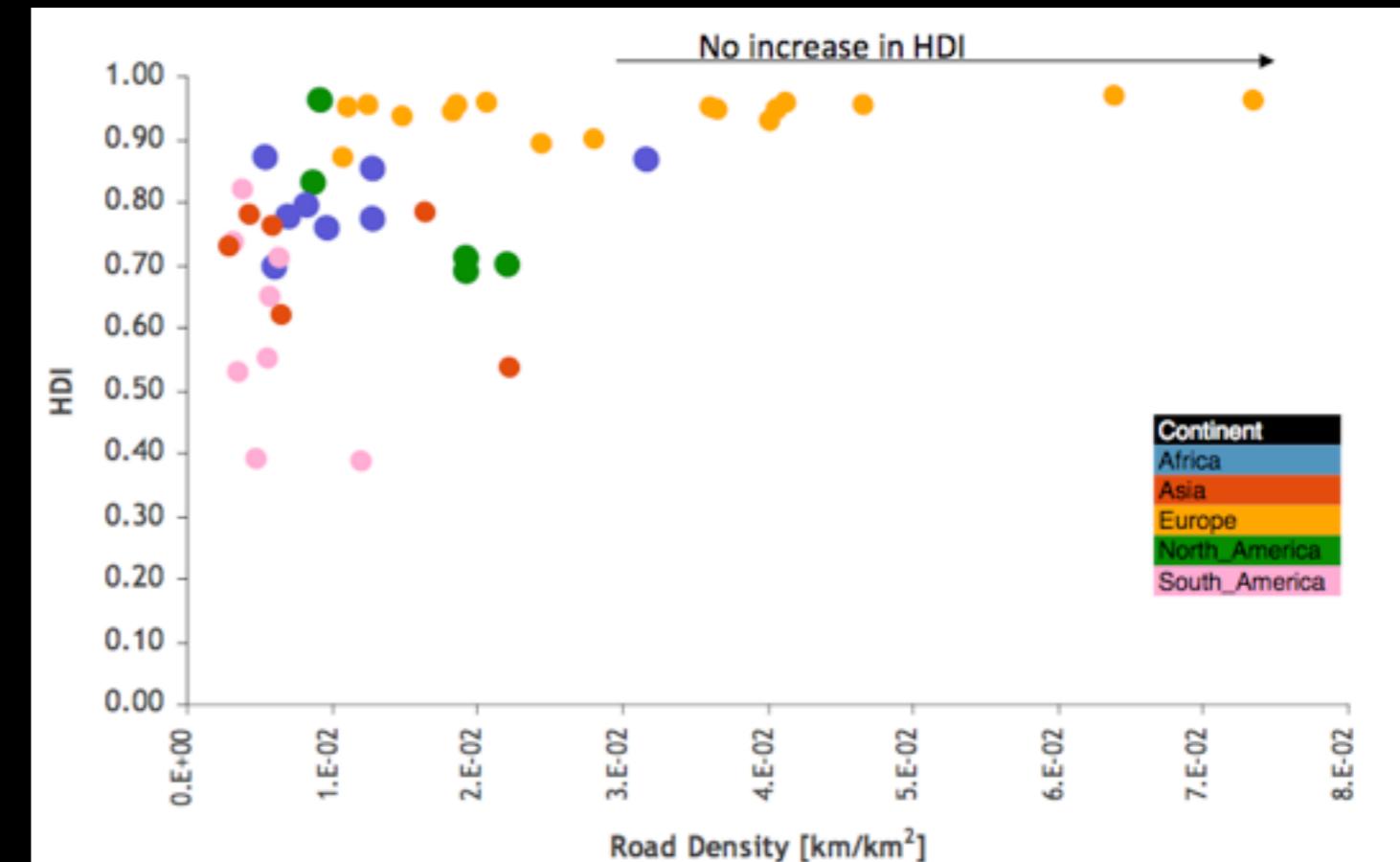


Data:  
VMAP 2 (2000)



# Global Road Patterns

- Road network related:
  - ▶ HDI
  - ▶ GDP
  - ▶ Energy

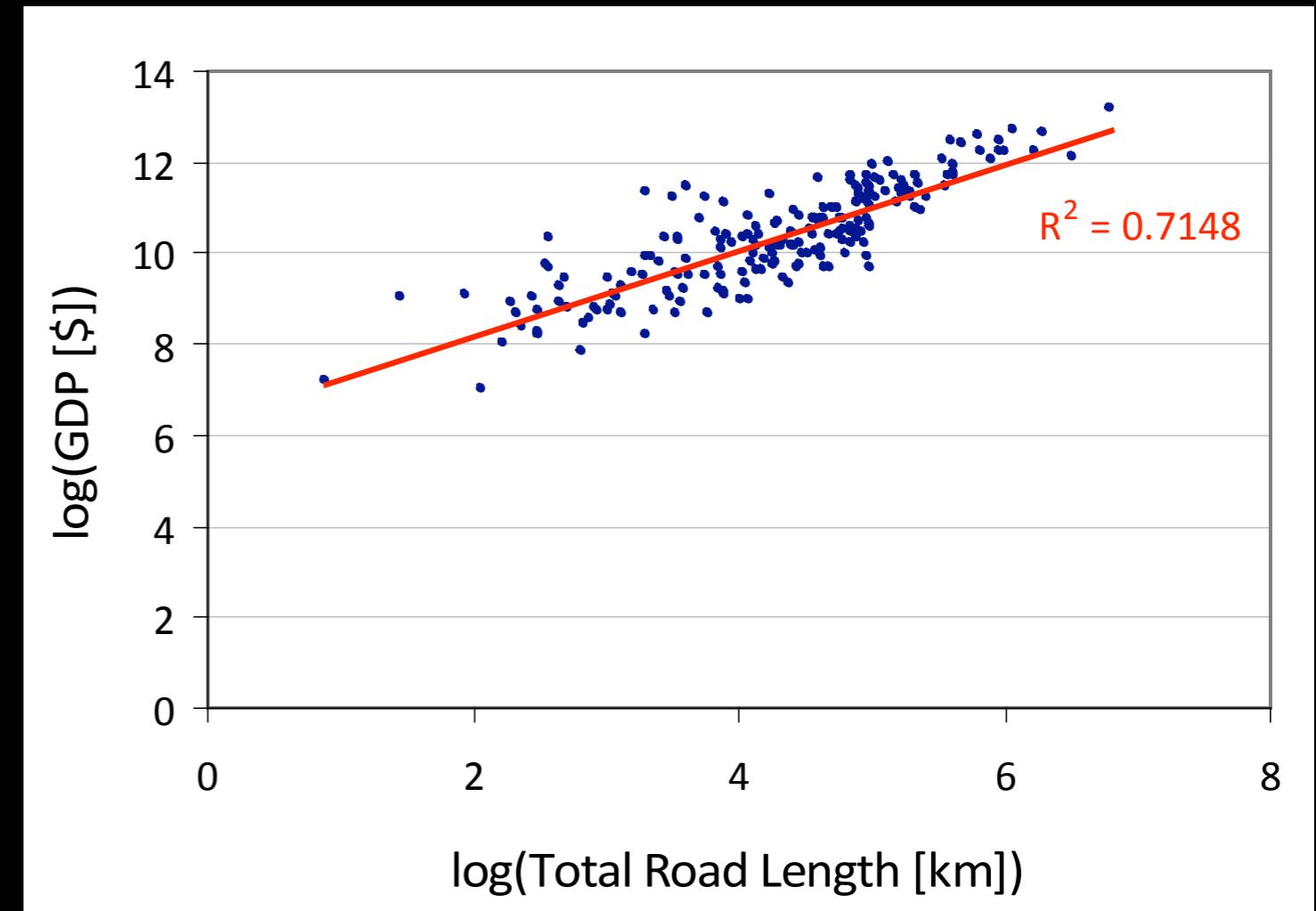


Source:  
VMAP 2 (2000)  
UN



# Global Road Patterns

- Road network related:
  - ▶ HDI
  - ▶ GDP
  - ▶ Energy

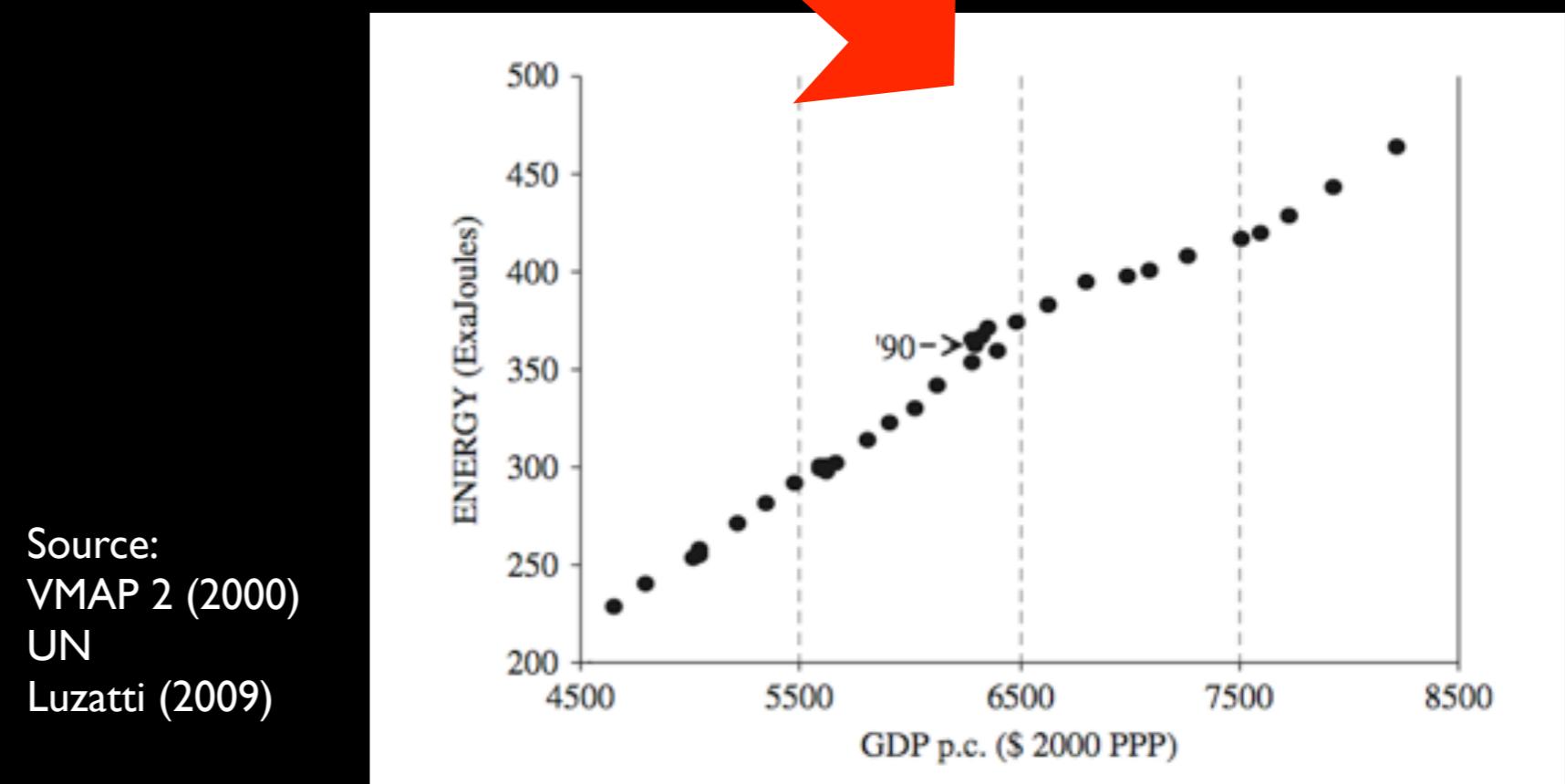
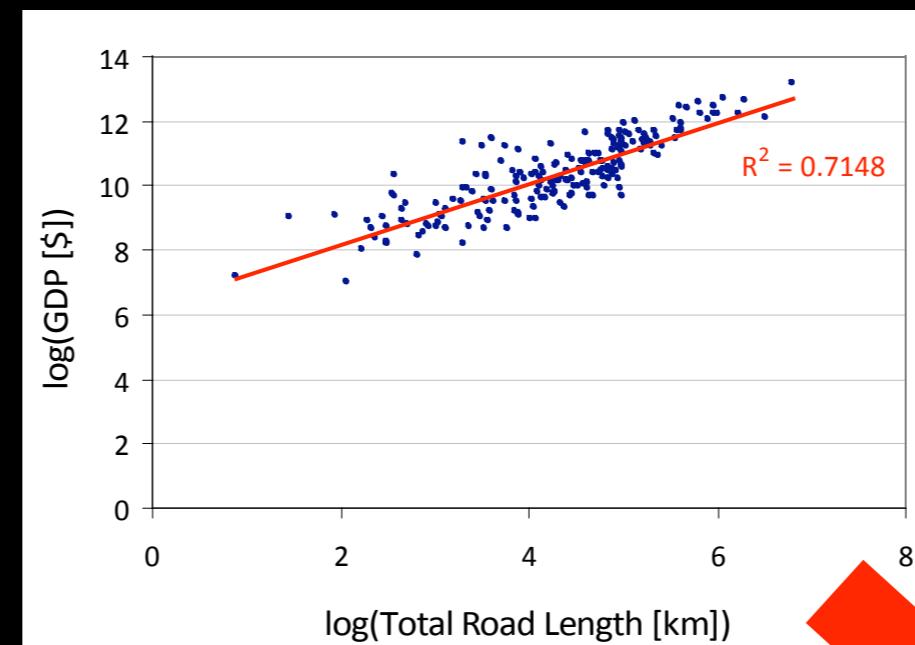


Source:  
VMAP 2 (2000)  
UN



# Global Road Patterns

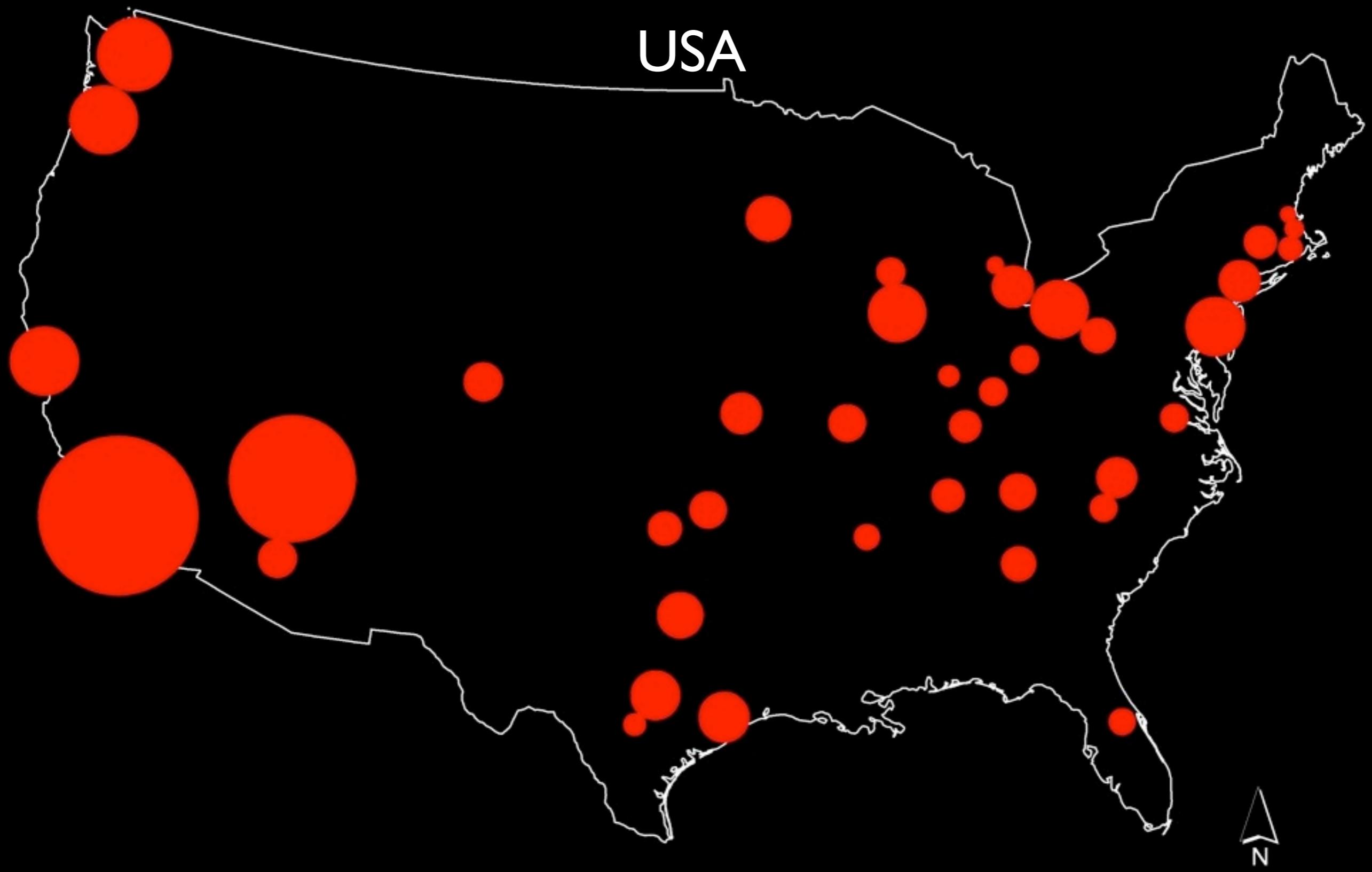
- Road network related:
  - ▶ HDI
  - ▶ GDP
  - ▶ Energy



# City Patterns



- ▶ Analysis of urban form:
  - Population density
  - Distance traveled to services
  - Road density



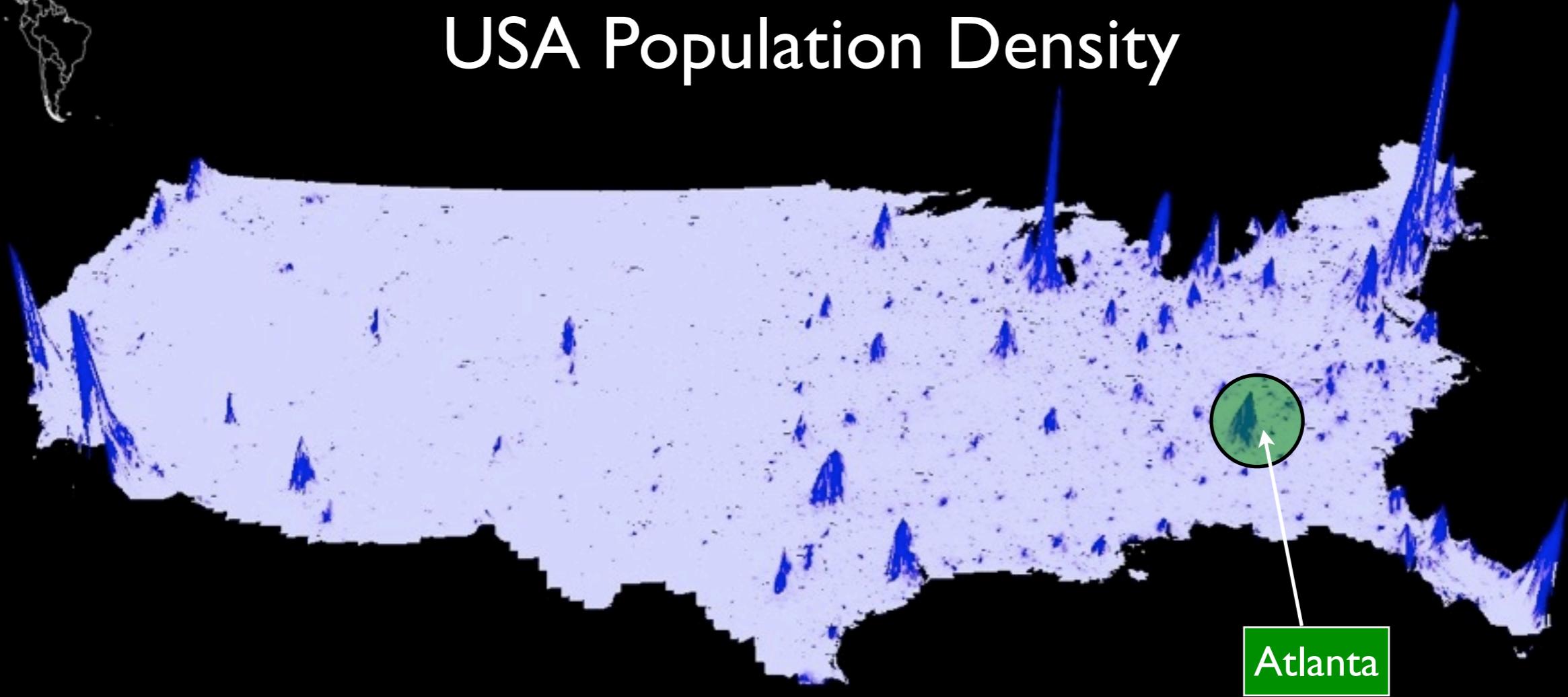
3.2 PhD Research

# USA





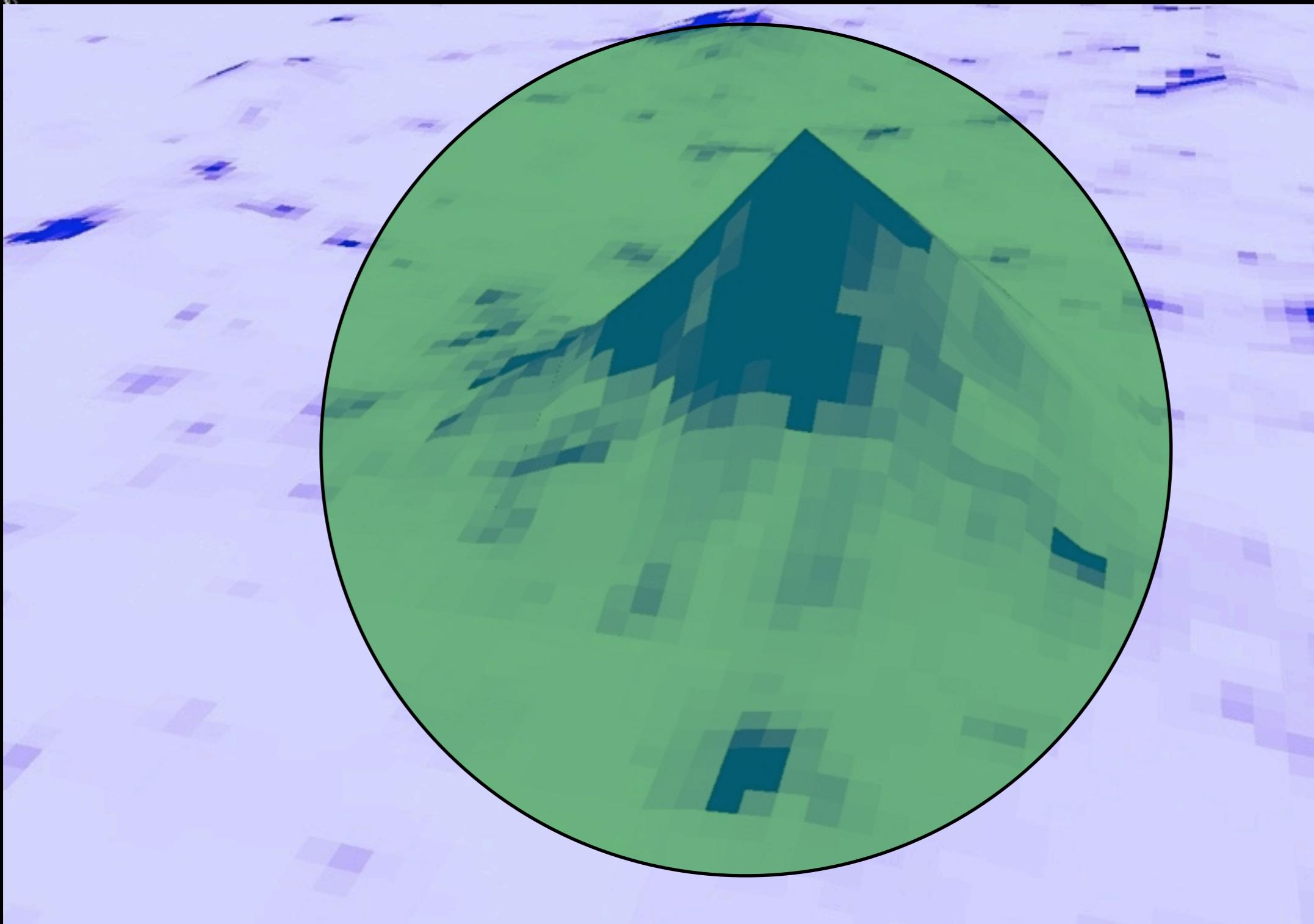
# USA Population Density



Data Source:  
US Census  
(2000)



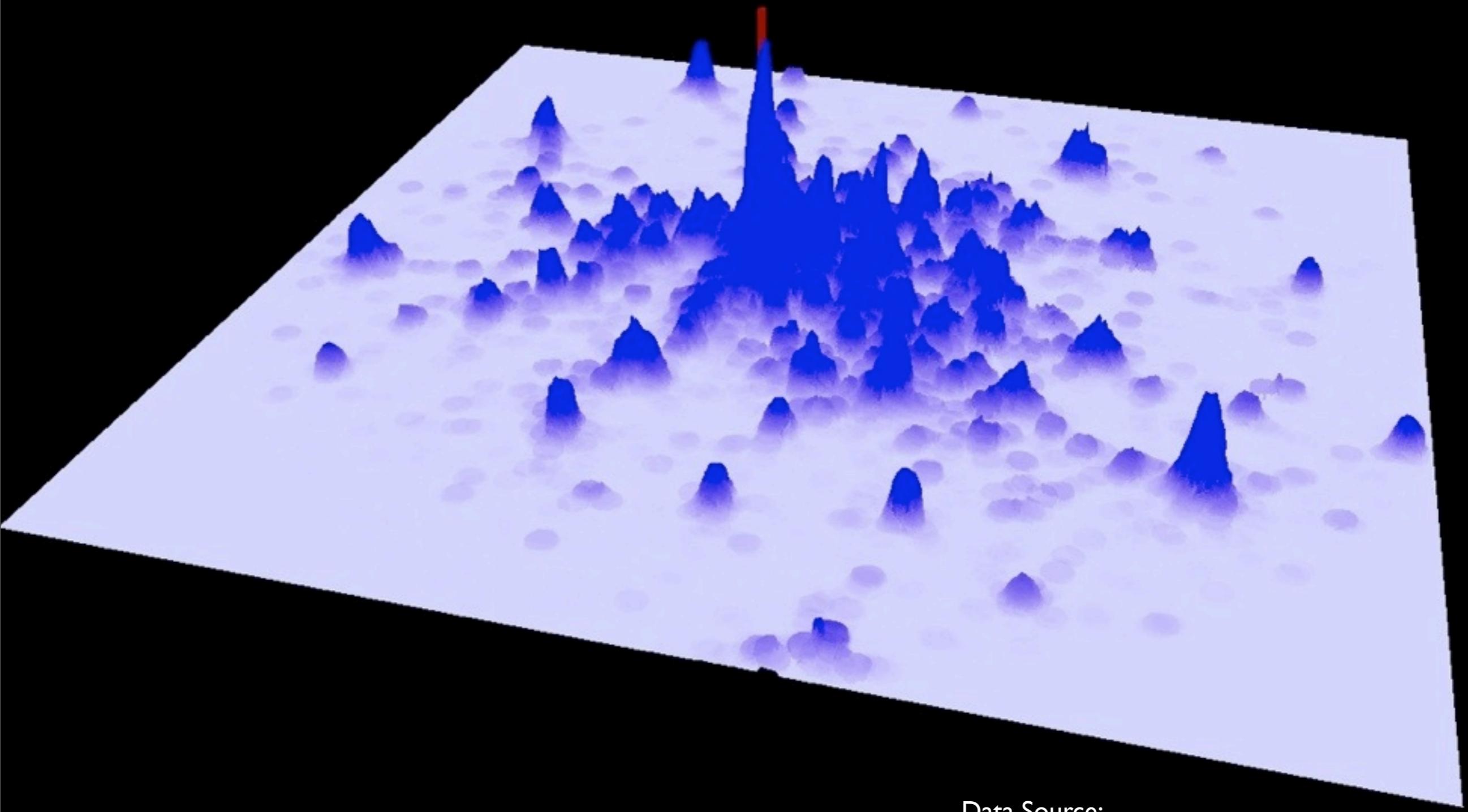
# Atlanta Population Density



Data Source:  
US Census  
(2000)



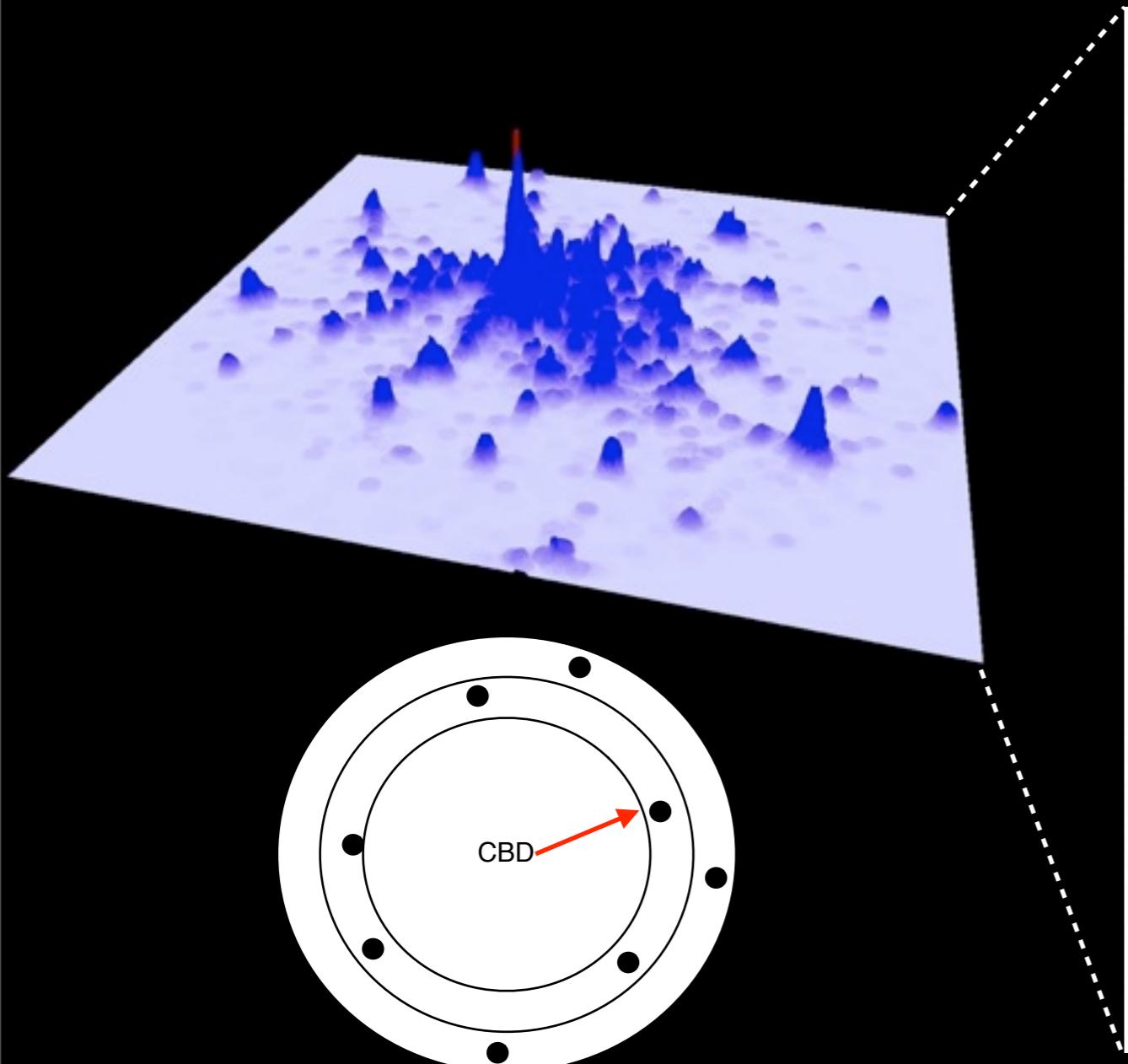
# Atlanta Service Density



Data Source:  
ESRI Business  
Analyst 2009



# Atlanta Service Density

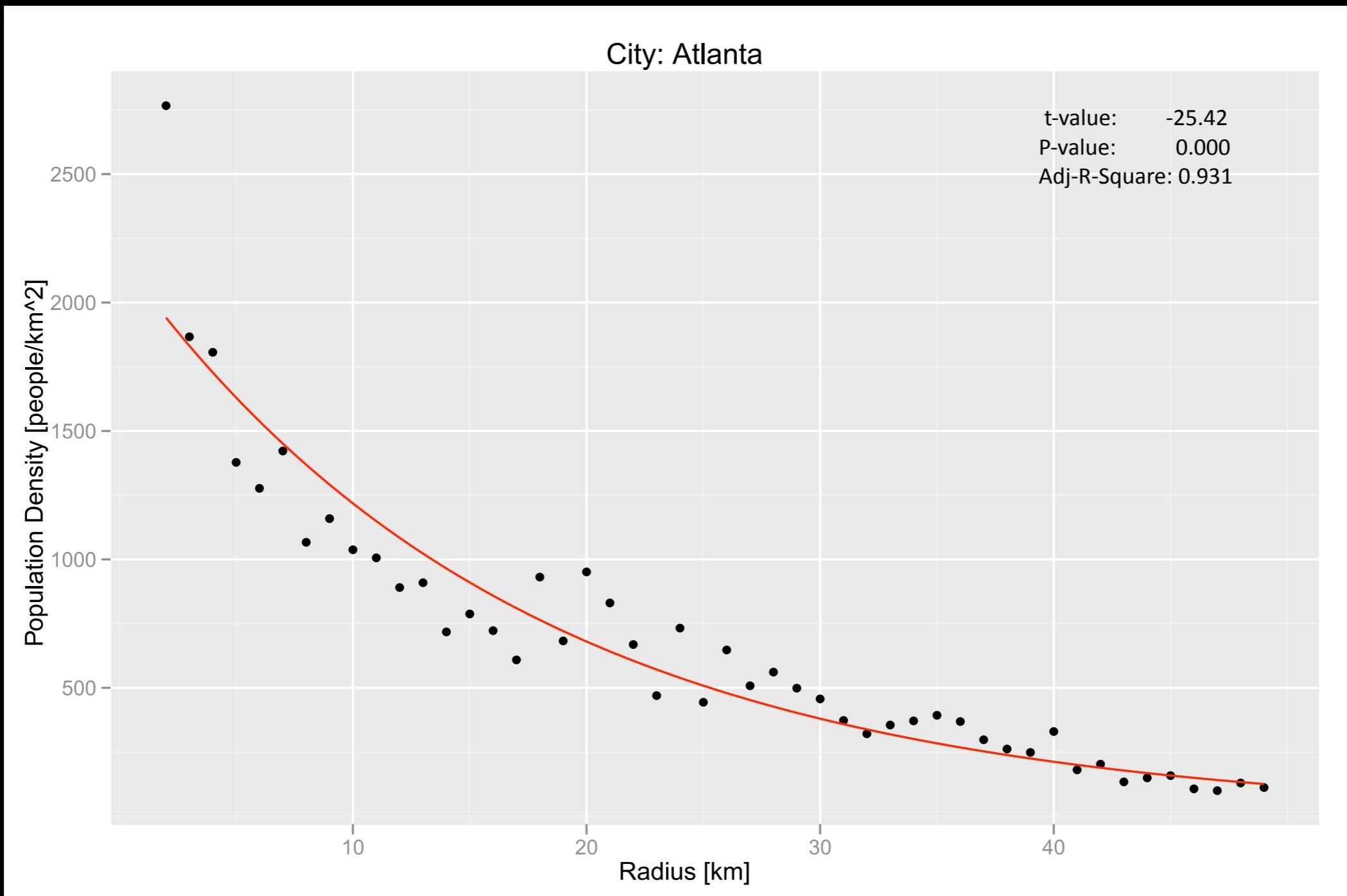


SERVICE	FREQUENCY [VISITS/WEEK]
Bank	0.370
Child care facility	0.382
Community/Civic center	1.078
Convenience store	2.556
Hair care	0.151
Hardware Store	1.379
Health club/Rec. facility	0.957
Laundry/dry cleaner	0.056
Library	0.254
Medical/Dental office	0.706
Pharmacy	2.044
Place of worship	0.900
Police/Fire station	0.002
Post Office	0.488
Restaurant	7.553
School	1.298
Senior care facility	0.204
Supermarket	1.173
Theater	0.823

Data Source:  
US Transportation Survey  
(Artessa Saldivar-Sali)



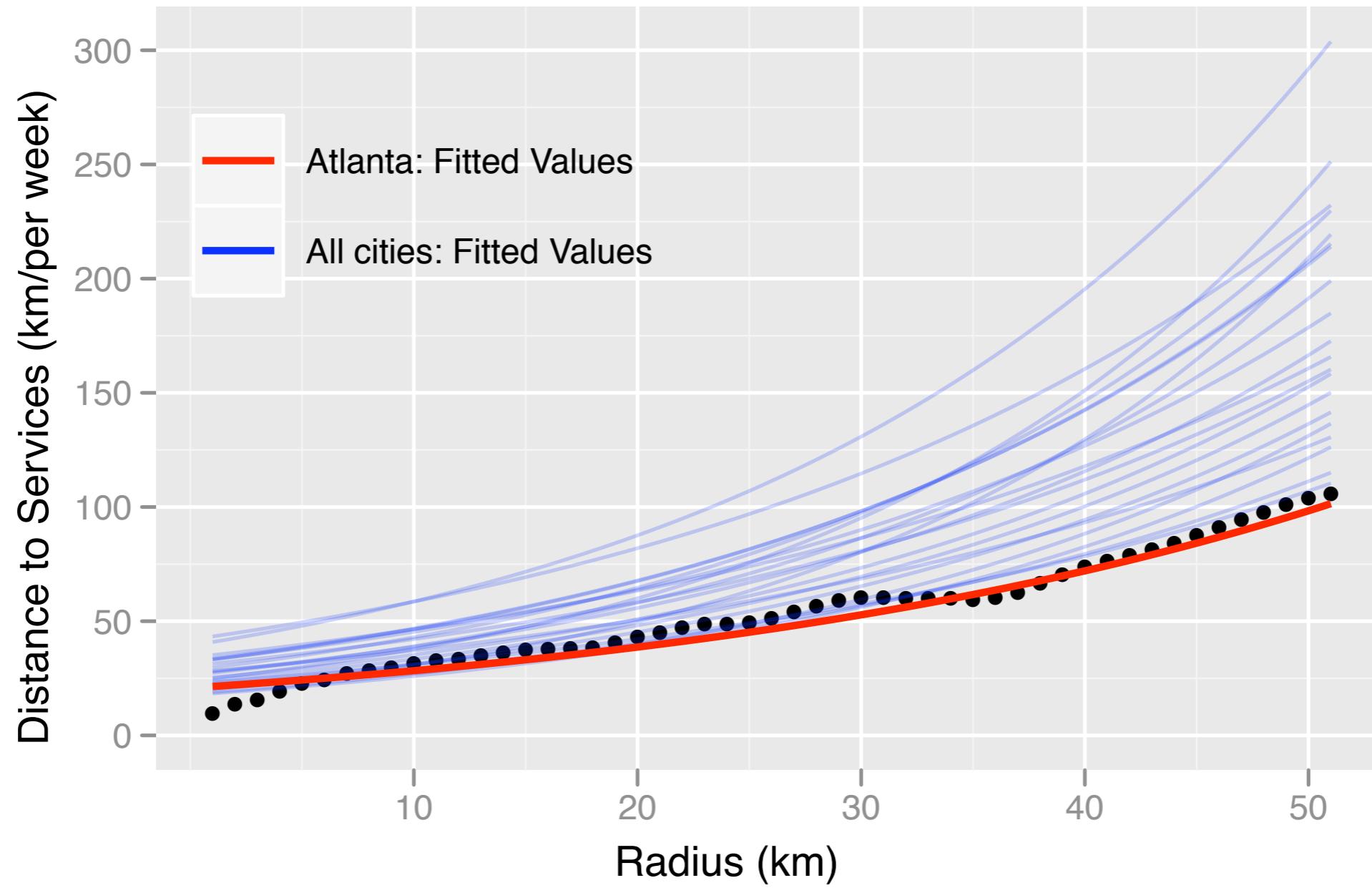
# Atlanta Population Density



Data Source:  
US Census  
(2000)

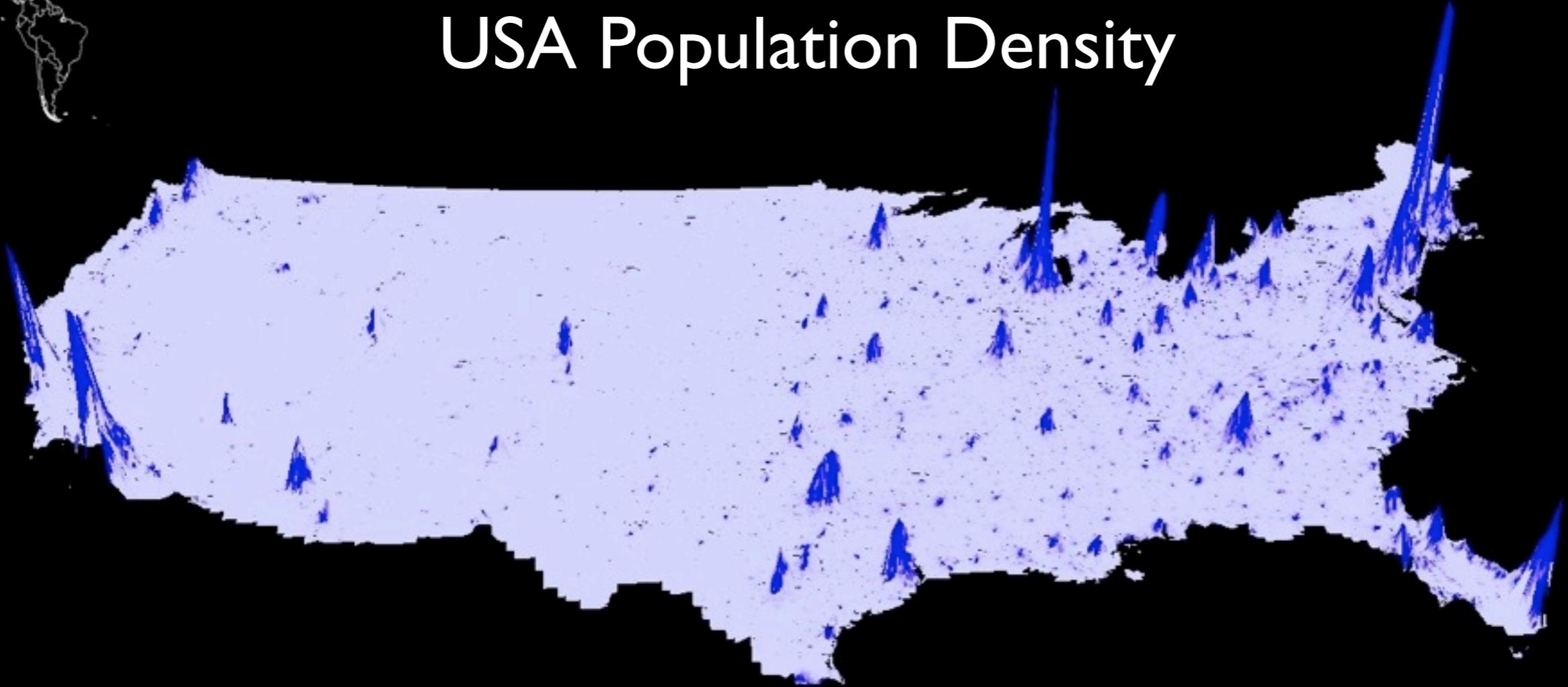


# Distance to Services





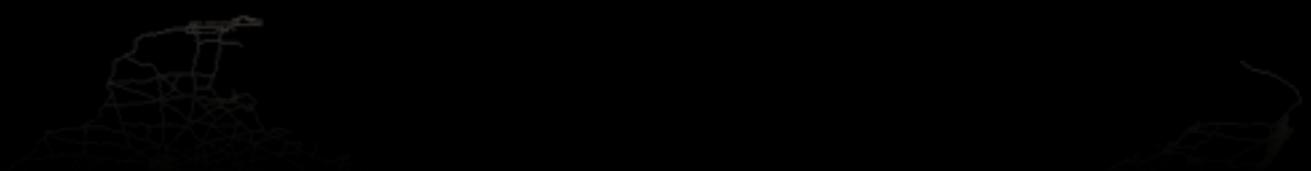
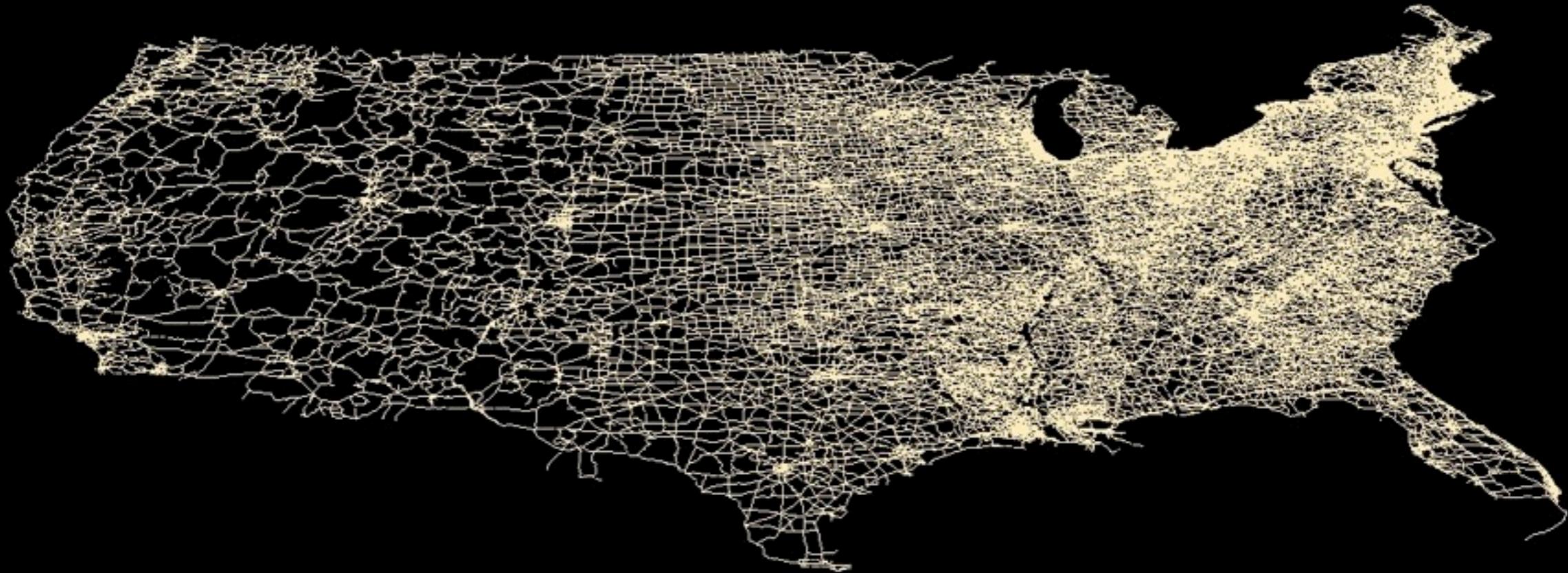
# USA Population Density



Data Source:  
US Census  
(2000)



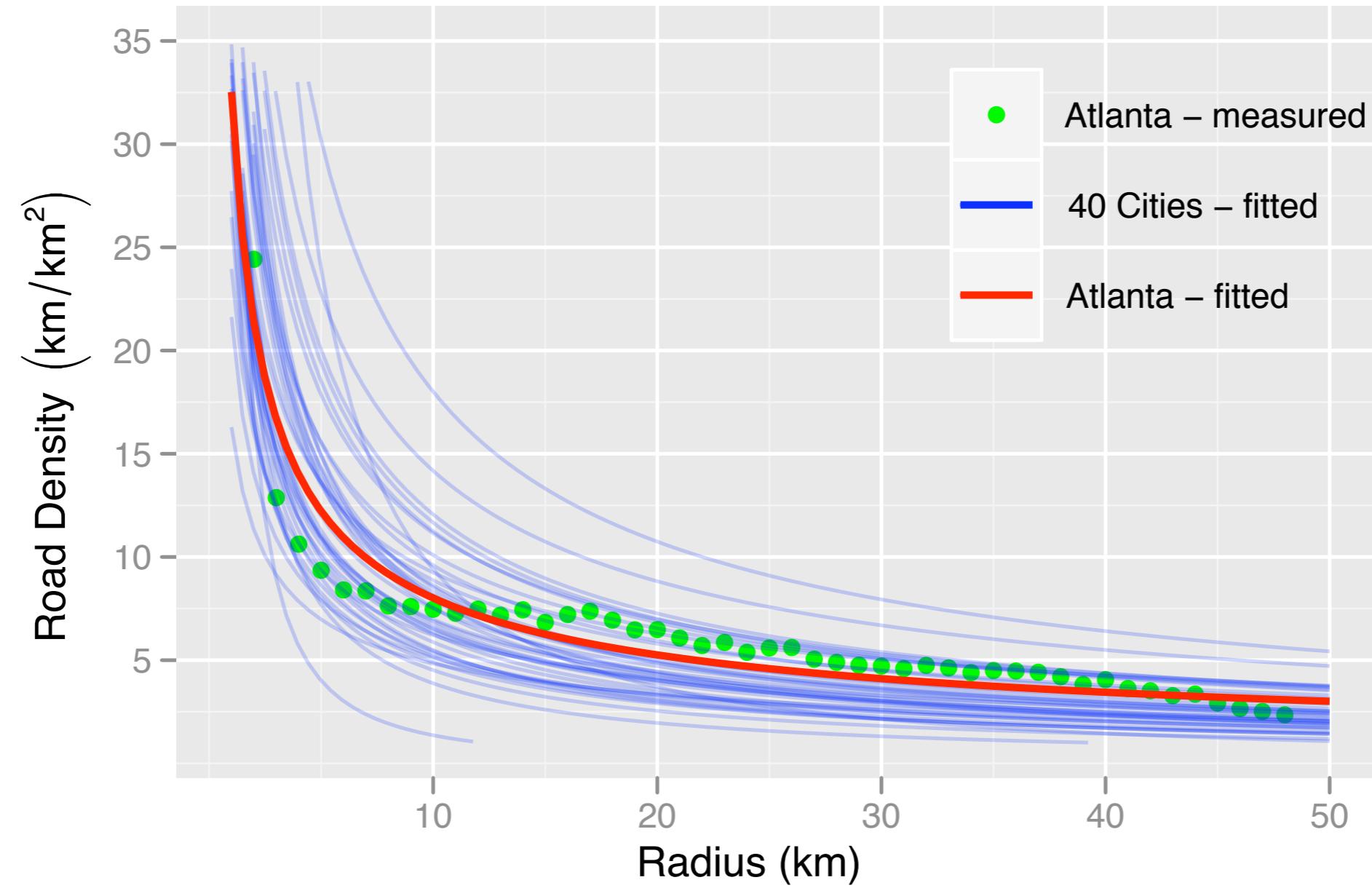
# USA Road Network



Data Source:  
US Tiger Line  
Files (2009)

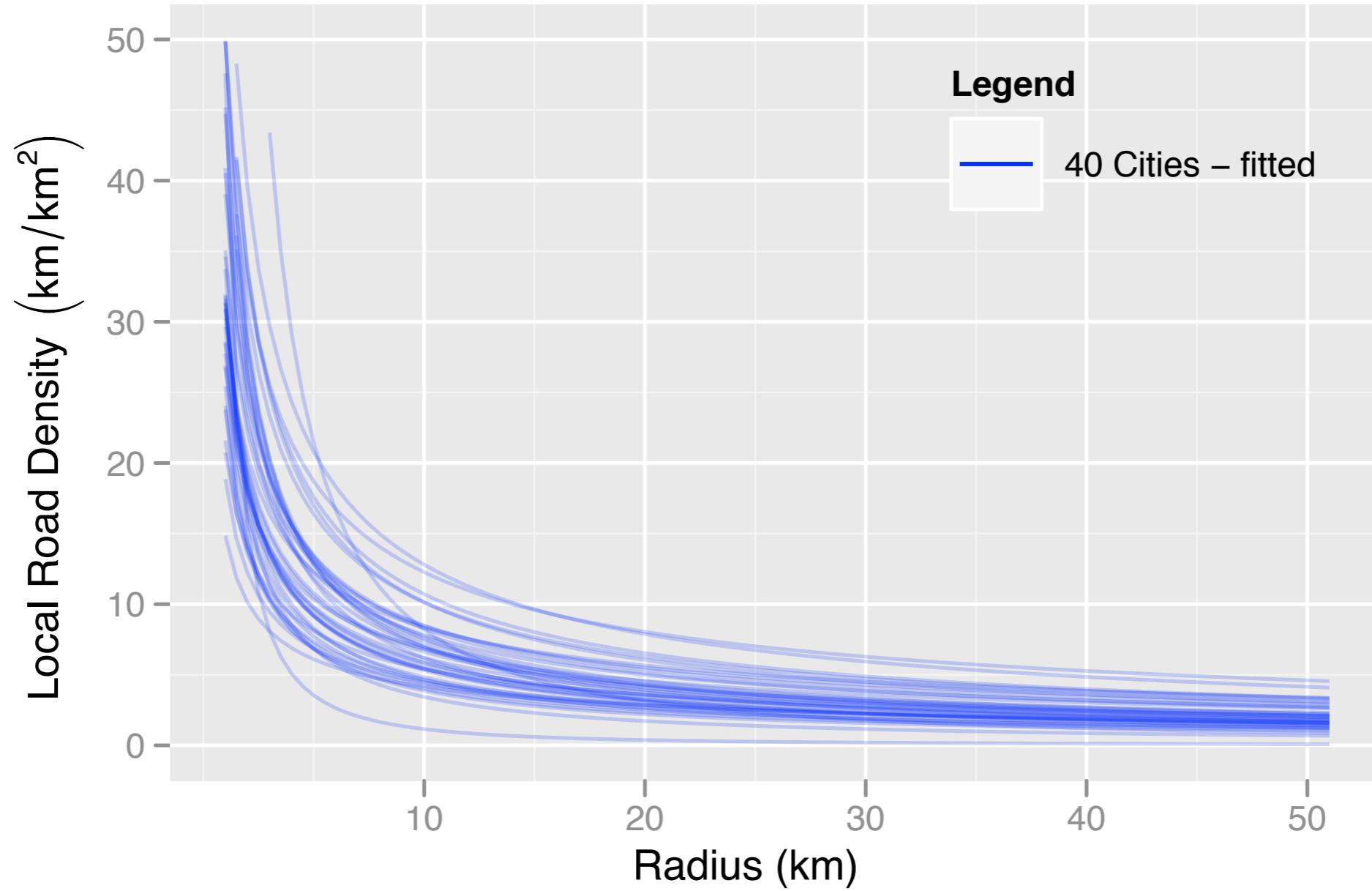


# Road Patterns



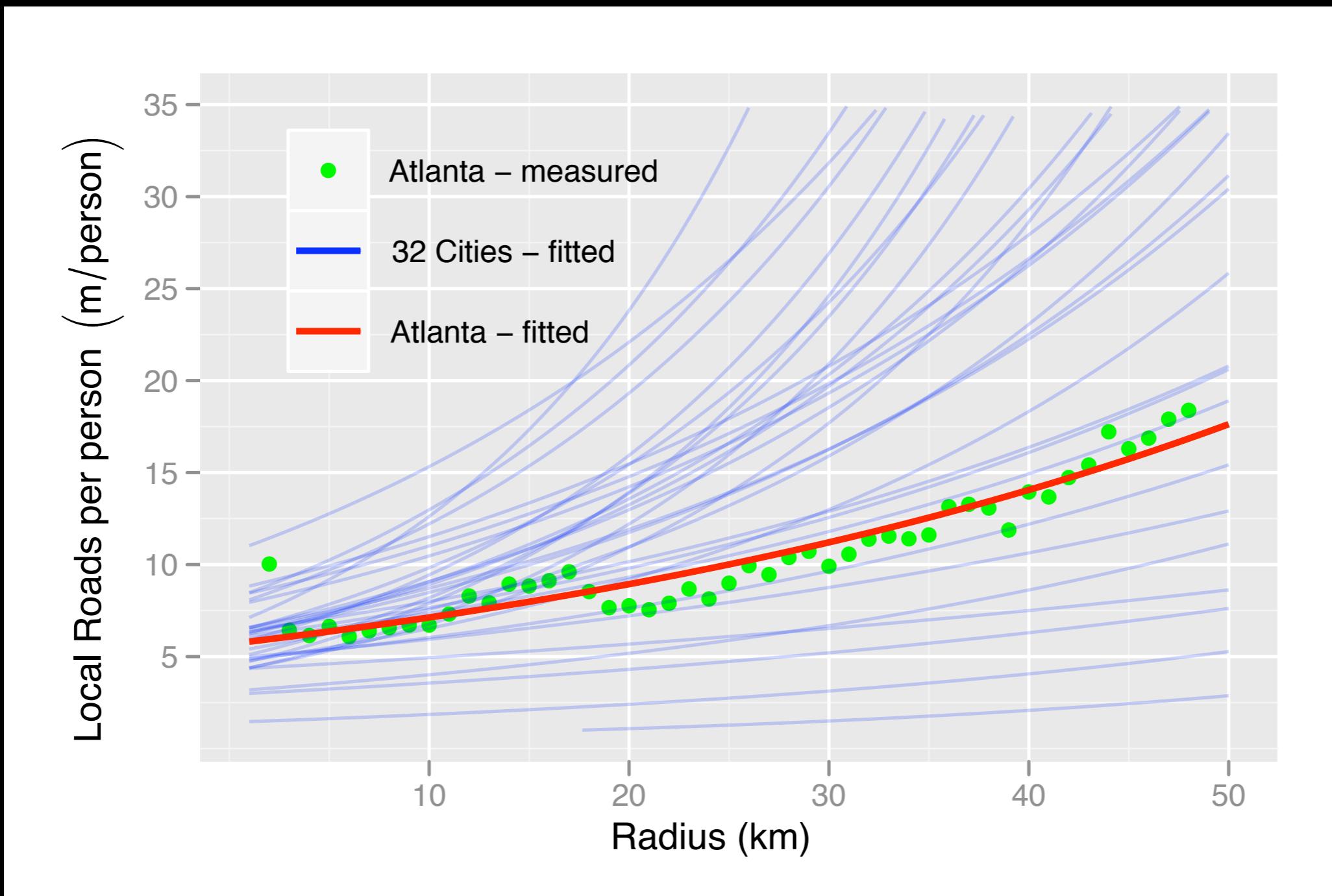


# Road Patterns





# Road Patterns



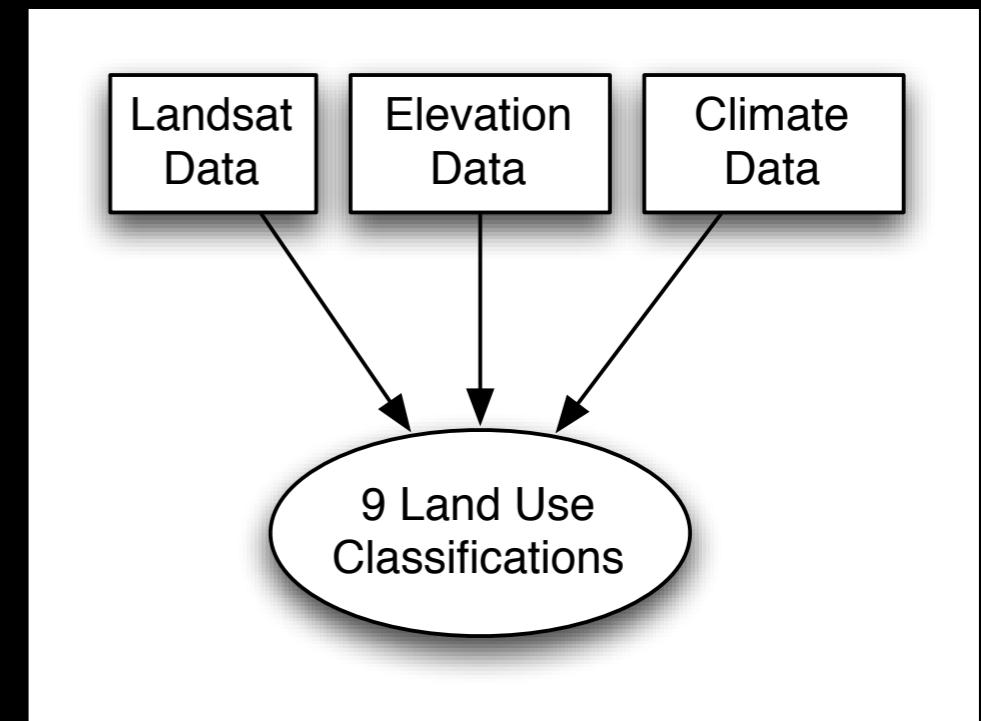
# Regional Land-Use Change - Costa Rica





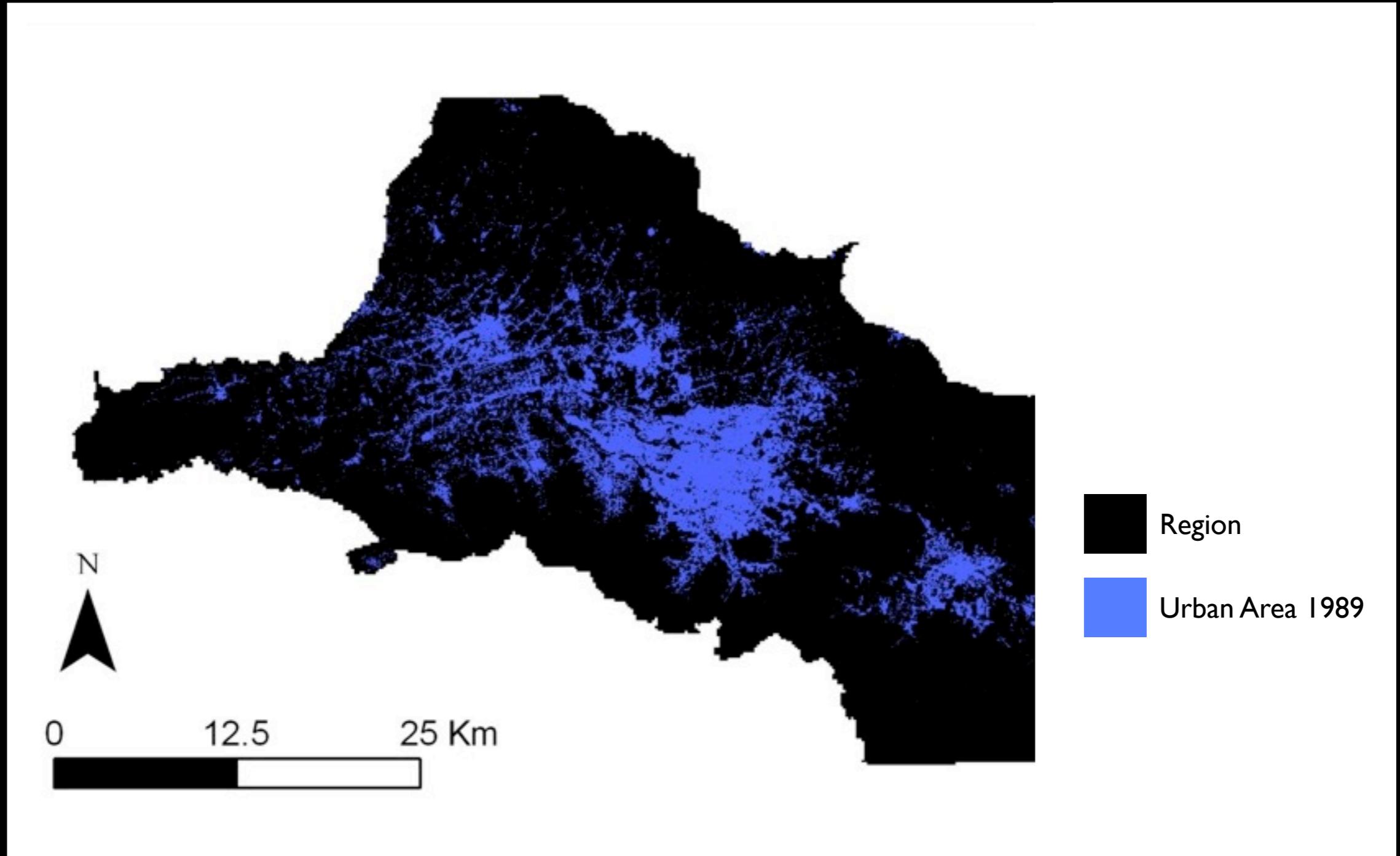
# Regional Land-Use Change - Costa Rica

- Multinomial logistic regression used to categorize land-use
- Data formatted and analyzed using ArcGIS, Python and R



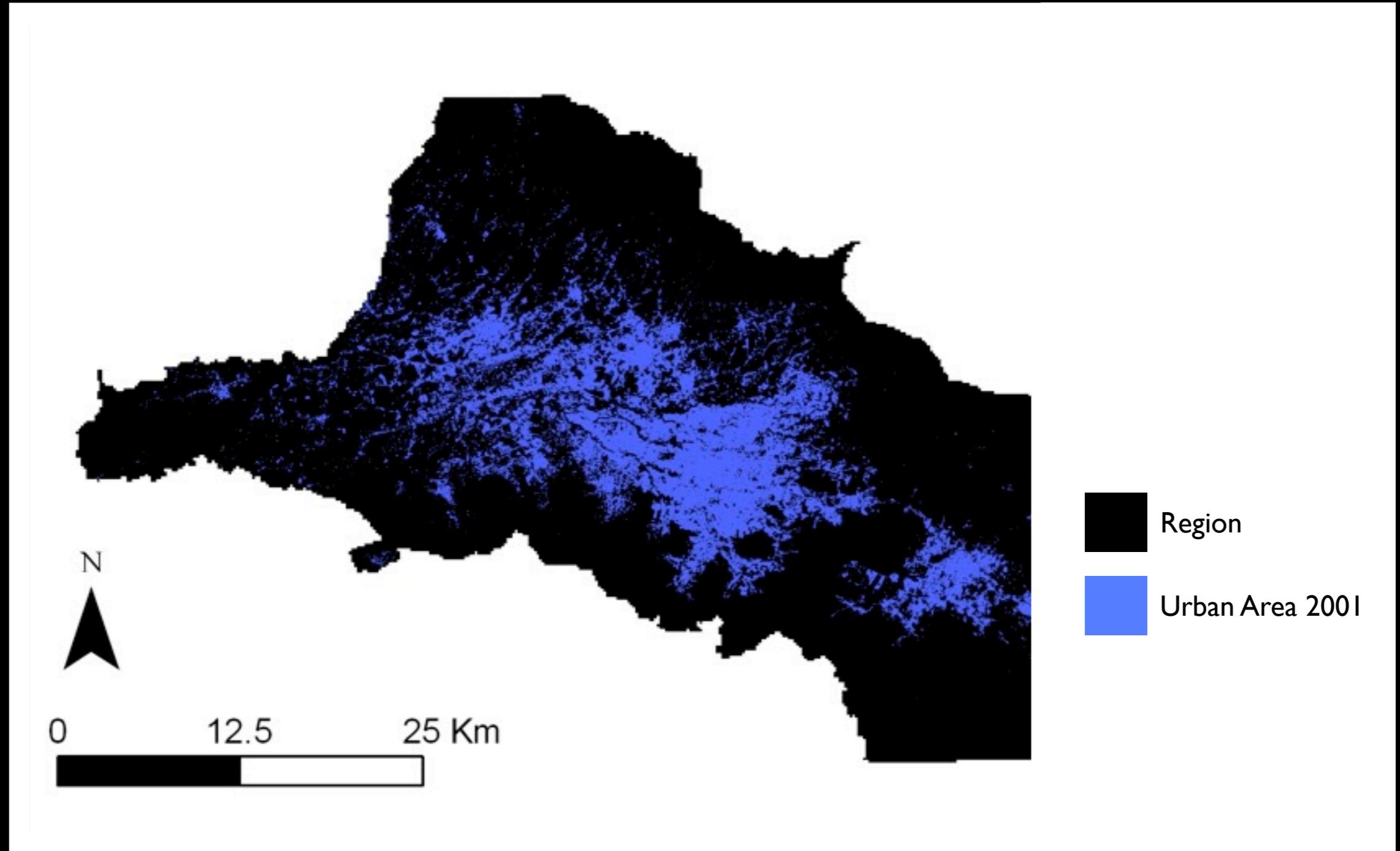


# Regional Land-Use Change - Costa Rica





# Regional Land-Use Change - Costa Rica

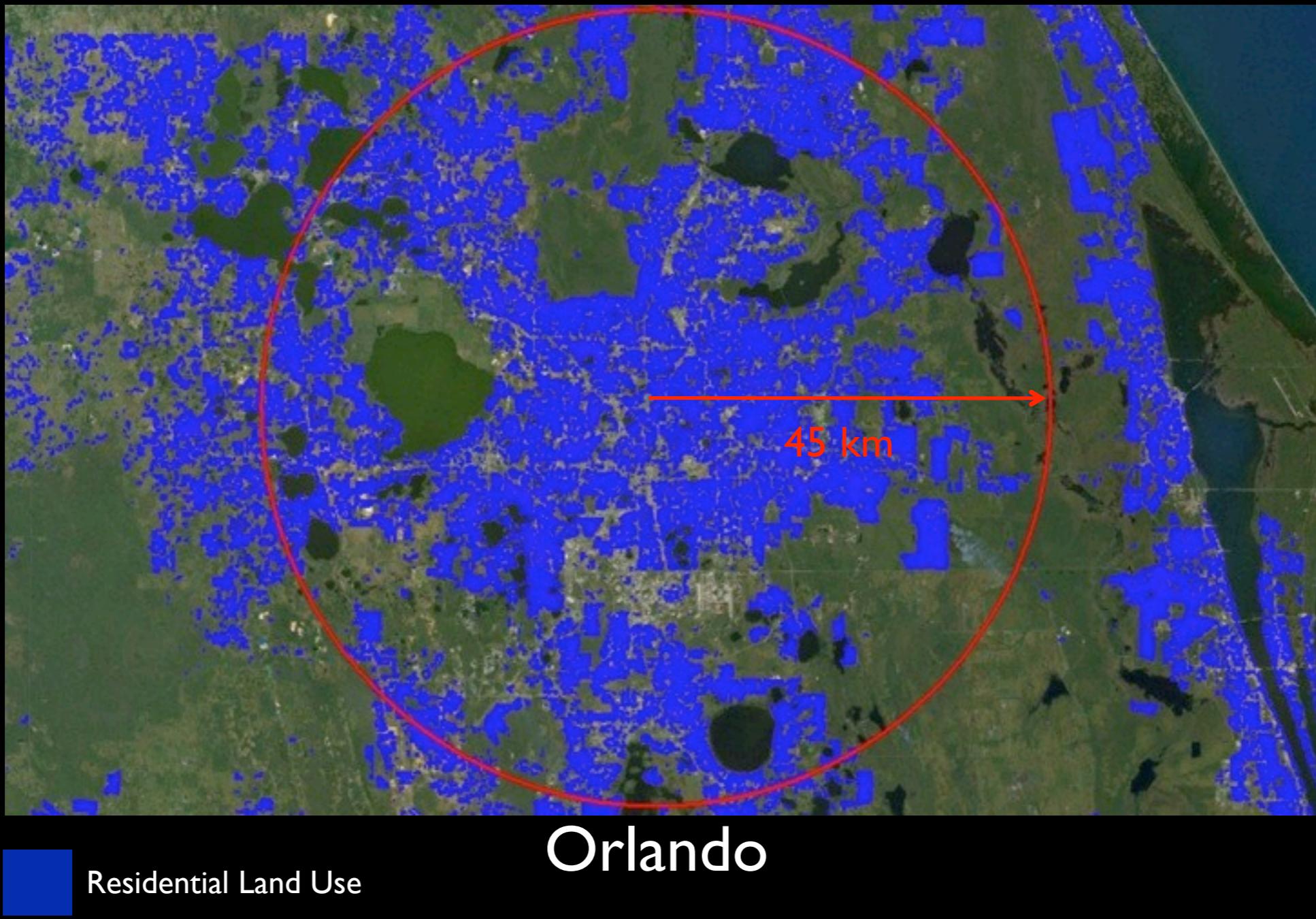


# Regional Growth Modeling



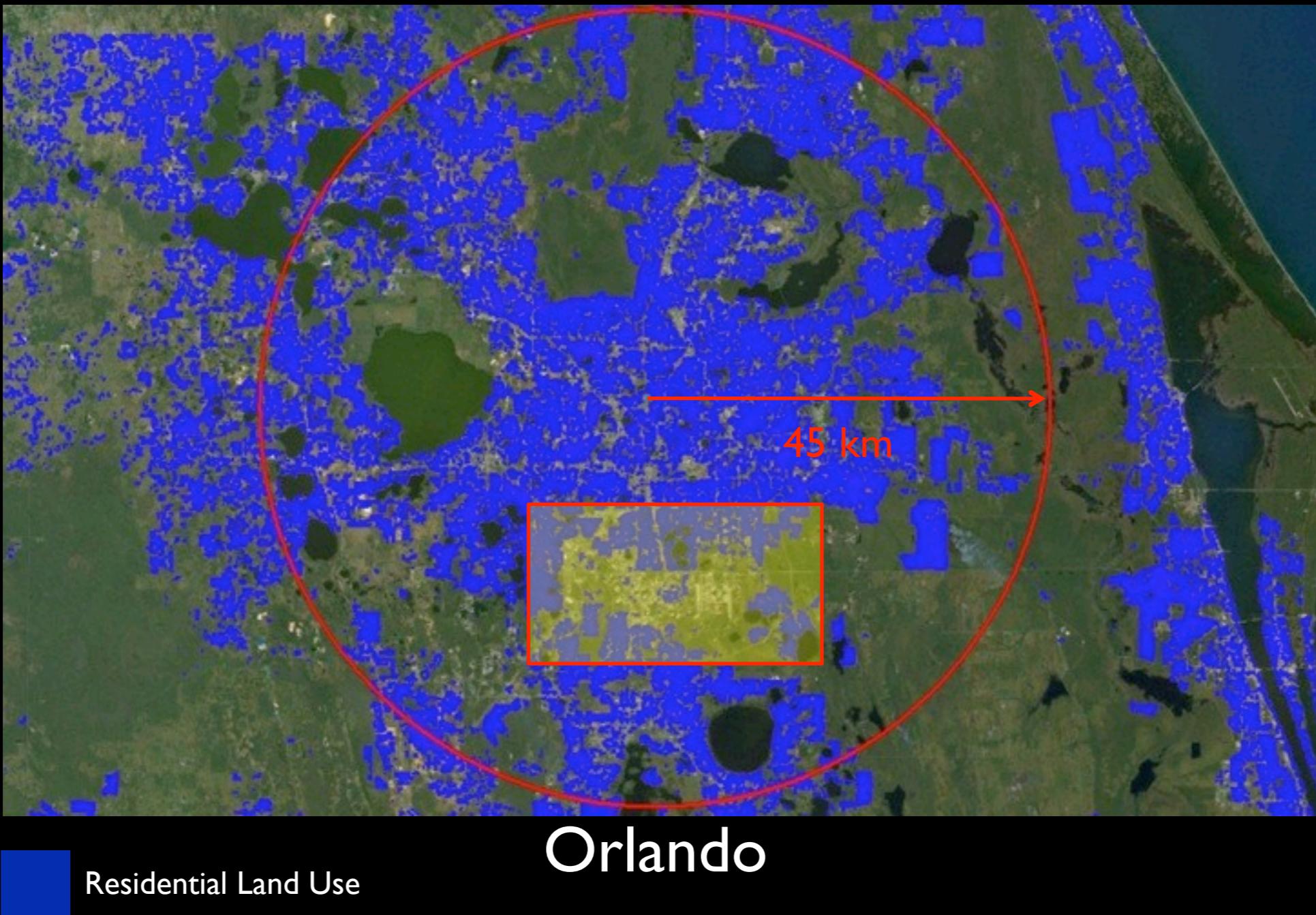


# Regional Growth Modeling



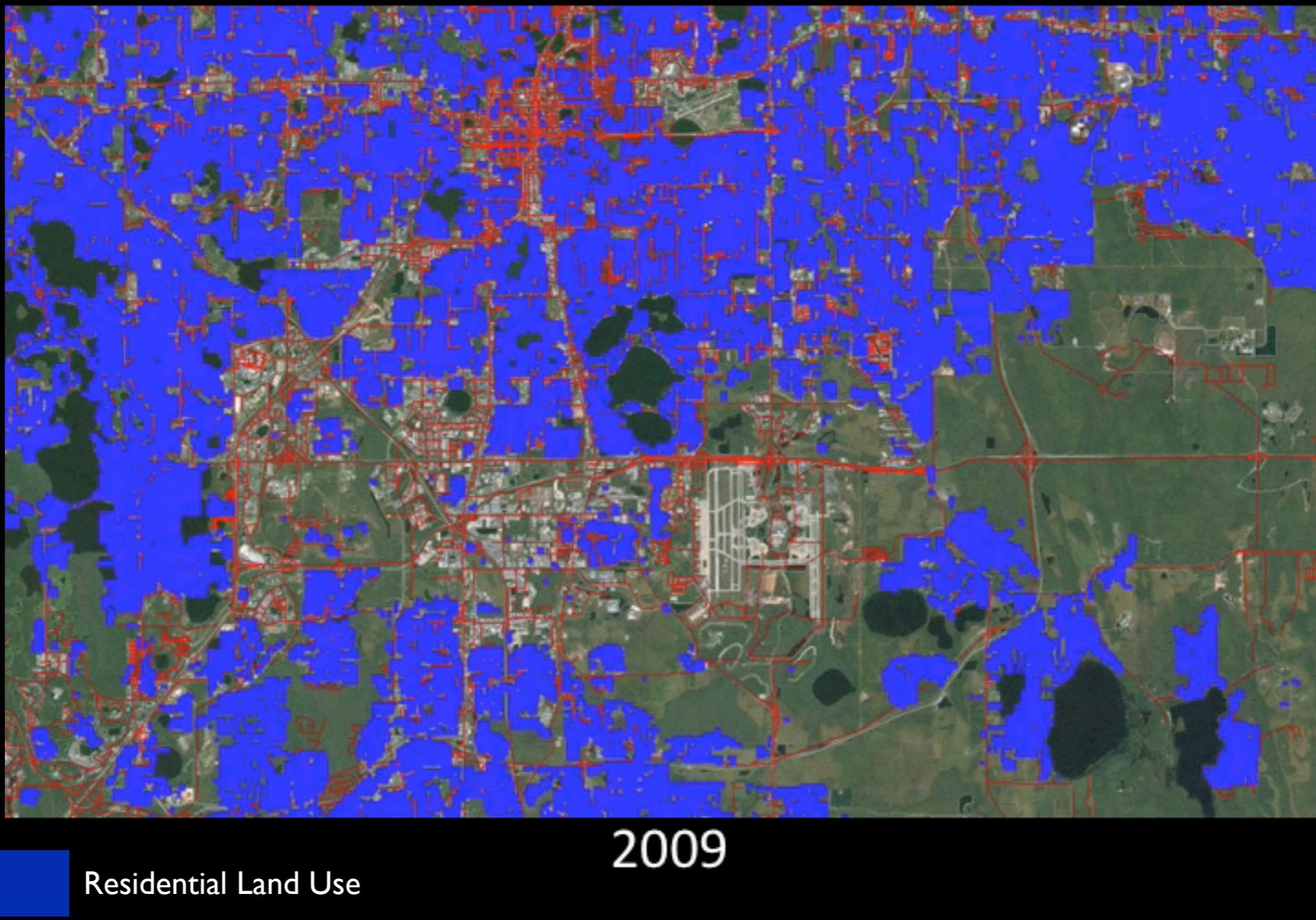


# Regional Growth Modeling

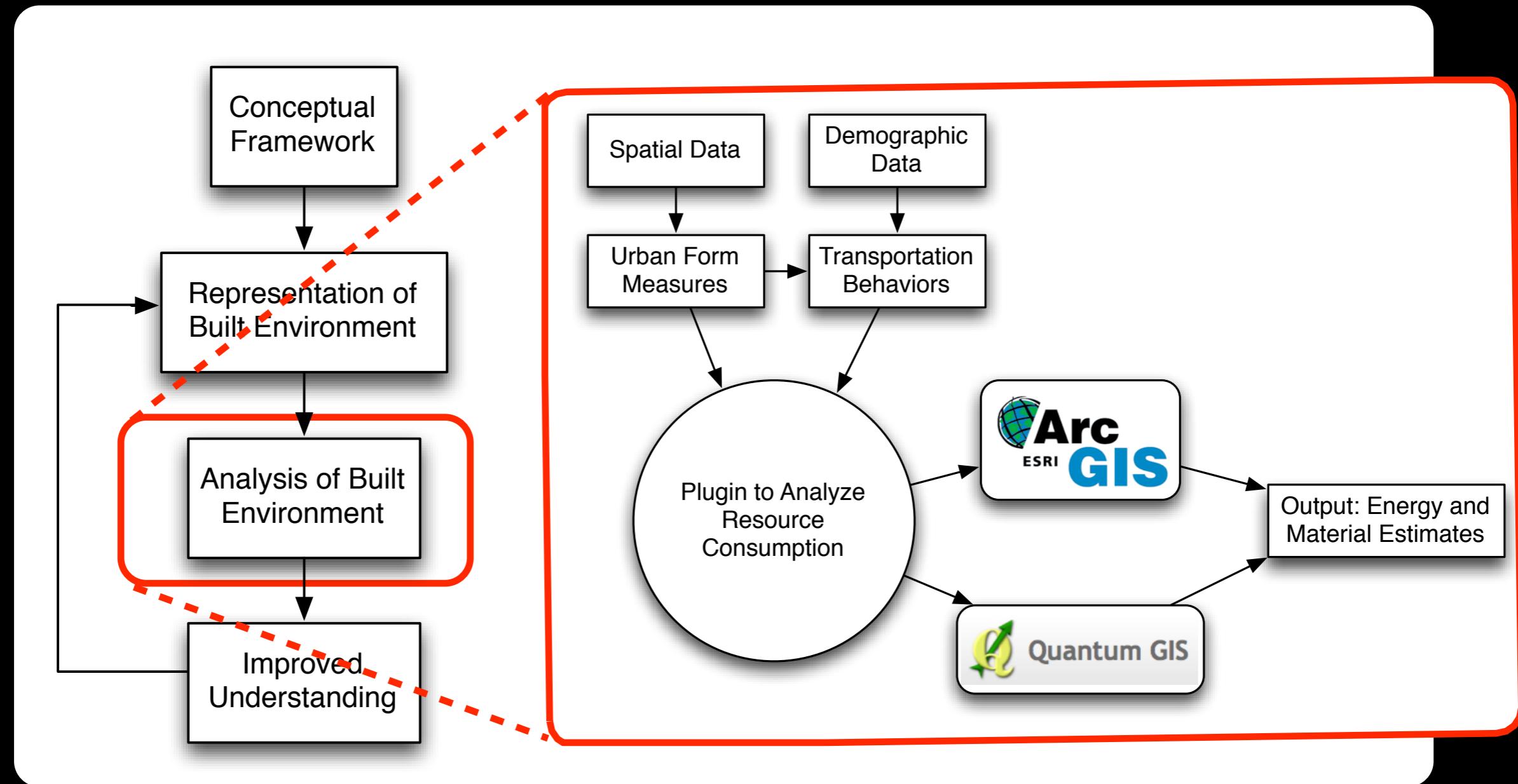




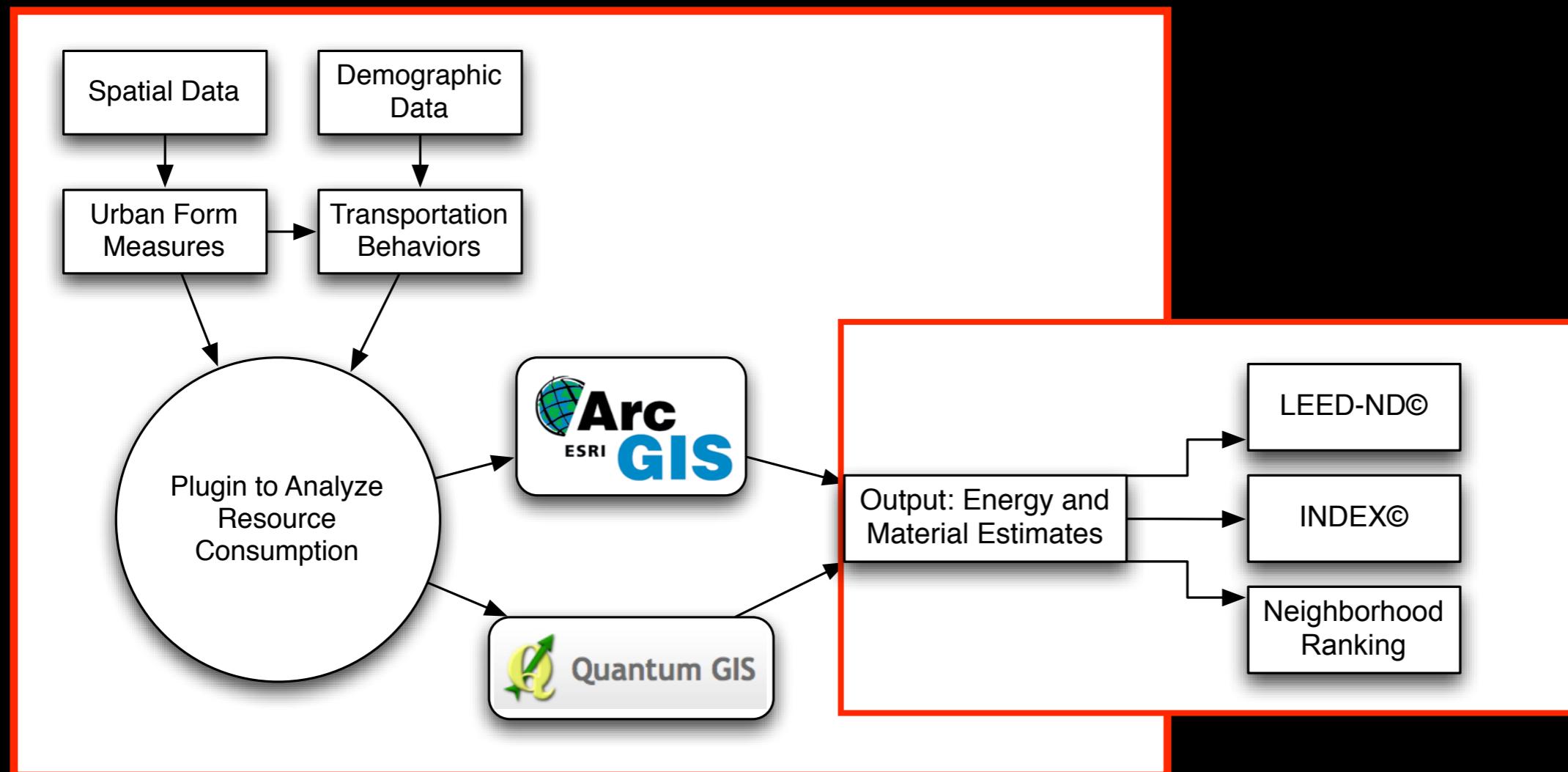
# Regional Growth Modeling



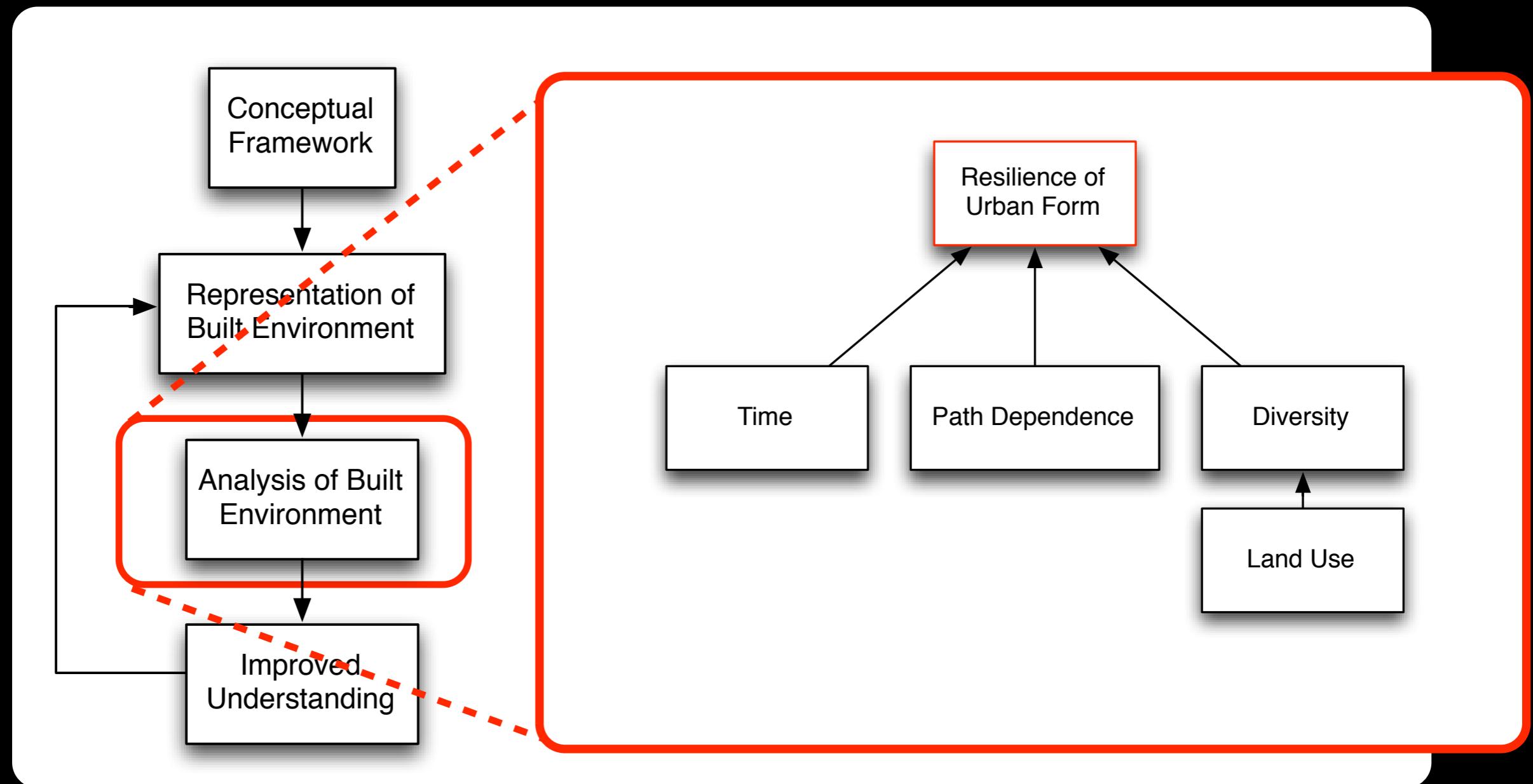
# Future Direction



# Future Direction



# Future Direction



# Conclusion

Develop and validate a method to analyze  
resource consumption of residential urban areas

# Masters Research - Summary

- ▶ June 2008 - Oral presentation: Mass Impact II: Cities and Climate Change  
“The urban metabolism of housing in New Orleans”. David Quinn, Cambridge
- ▶ May 2008 - “Modeling the Resource Consumption of Housing in New Orleans using System Dynamics”. MIT Masters Thesis
- ▶ January 2008 - Booklet, “GreeNOLA:A strategy for a Sustainable New Orleans”, City of New Orleans, Earthea Nance, Wynecta Fisher, Jeffrey Schwartz, David Quinn, New Orleans
- ▶ March 2007 - Poster:Holcim Conference, “Urban Metabolism: Ecologically sensitive construction for a sustainable New Orleans”, David Quinn, Shanghai

# PhD Research - Summary

- ▶ Working Paper “Using LEED for Neighborhood Development to compare Resource Efficiency in US Cities”, David Quinn, Artessa Saldivar-Sali and John E Fernandez
- ▶ August 2010 - Paper: SimBuild “Estimating Material Usage of Road Infrastructure in US Cities”, David Quinn and John E Fernandez, New York
- ▶ June 2010 - Poster: Urban Environmental Pollution, “Quantifying the performance of US Cities using LEED-ND”, David Quinn, Artessa Saldivar-Sali and John E Fernandez, Boston
- ▶ March 2010 - Poster: MIT Energy Conference, “Urban Energy Consumption”, Daniel Wiesmann and David Quinn, Cambridge
- ▶ June 2009, - Oral Presentation: International Society of Industrial Ecology “Urban Sustainability: Indicators, Patterns and Systems Dynamics”, David Quinn and Artessa Saldivar-Sali, Lisbon
- ▶ March 2009 - Poster: MIT Energy Conference, “Urban Metabolism of Lisbon”, Poster:, Artessa Saldivar-Sali, Daniel Wiesmann, David Quinn and Leonardo Rosado, Cambridge
- ▶ January 2009 - Poster: Alliance for Global Sustainability, “Urban Metabolism of Lisbon: ReMAP”, David Quinn, Zurich