Accessibility:
The Land Use-Transportation Link

Day 5

11.953

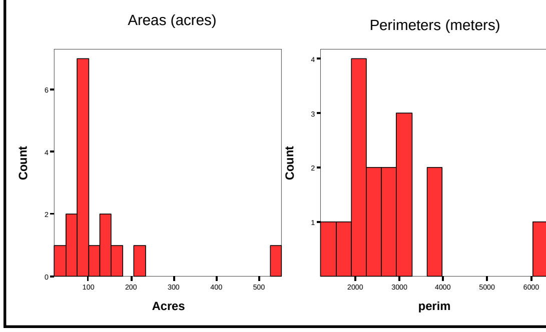
Content

- Review of Introductory Assignment
- Accessibility: History and Definitions
- Types of Accessibility Measures
- Example Applications
- Accessibility: Indicator or Variable?
- Practical Uses of Accessibility Measures

Introductory Assignment

- Defining Neighborhoods
  - Primarily Physical: 10
  - Physical-Social-Economic: 9
  - “Other”
    - “Daily/Weekly Patterns”: 2
    - Variations in concept of “nearness”
- Example characteristics
  - “atmosphere”, housing stock age/type, activity types, aesthetics
  - “walkability”
  - Clear boundaries: physical, monuments, street patterns
  - “status”

Introductory Assignment

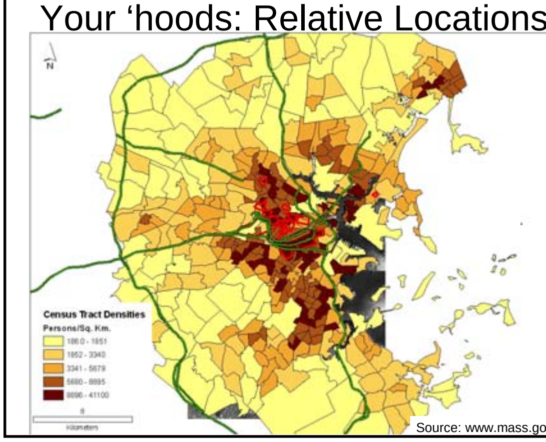


Introductory Assignment

Neighborhood Summaries

	Perimeter (m)	HAs	Acres
N	16	16	16
Mean	2827.75	51.83	128.08
Median	2642.00	35.98	88.90
Minimum	1227	8	21
Maximum	6383	224	553

Your ‘hoods: Relative Locations



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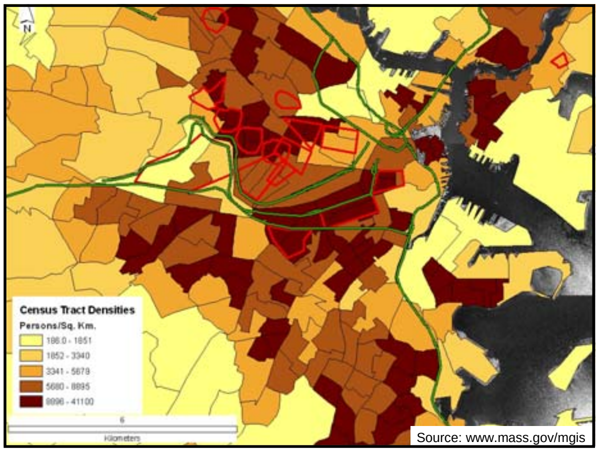
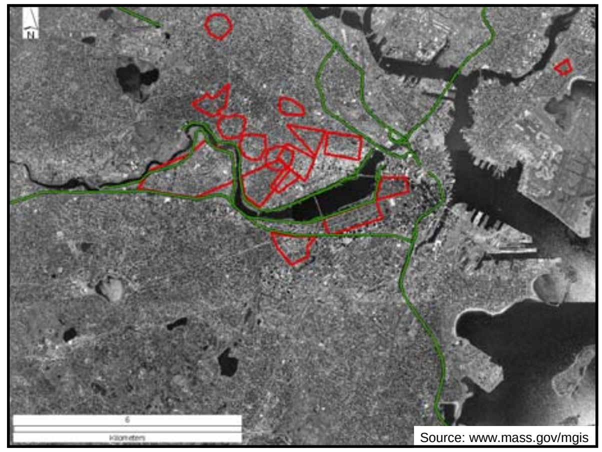
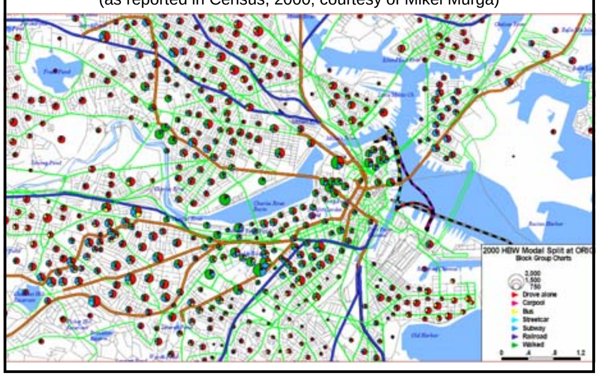
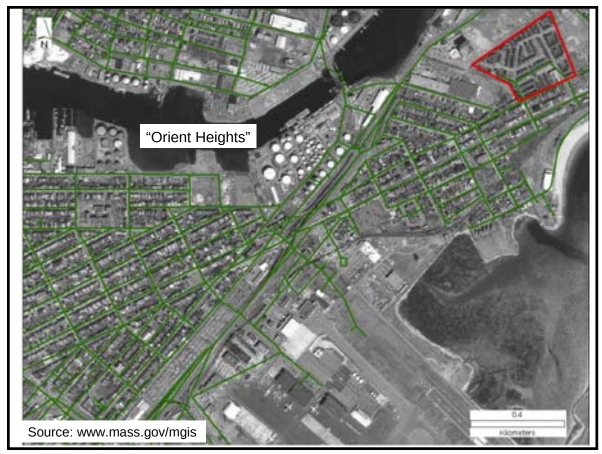


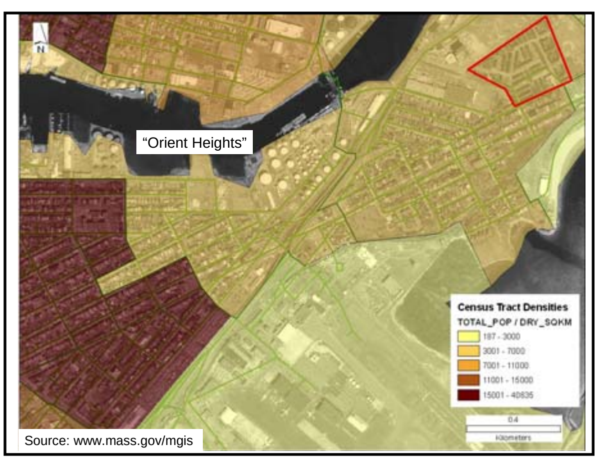


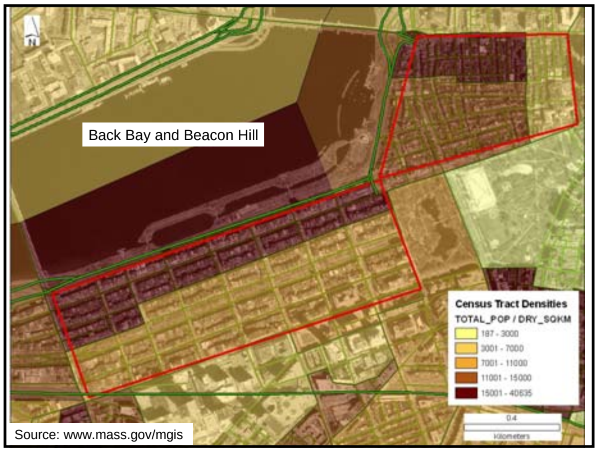
Journey to Work Mode Choice

(as reported in Census, 2000; courtesy of Mikel Murga)

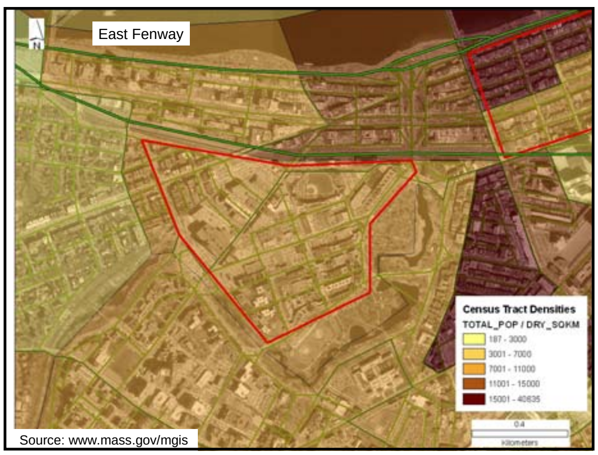







Back Bay and Beacon Hill
Census Tract Densities
TOTAL_POP / DRY_SQKM
187 - 3000
3001 - 7000
7001 - 11000
11001 - 15000
15001 - 40635
0.4
Kilometers
Source: www.mass.gov/mgis


East Fenway
0.4
Kilometers
Source: www.mass.gov/mgis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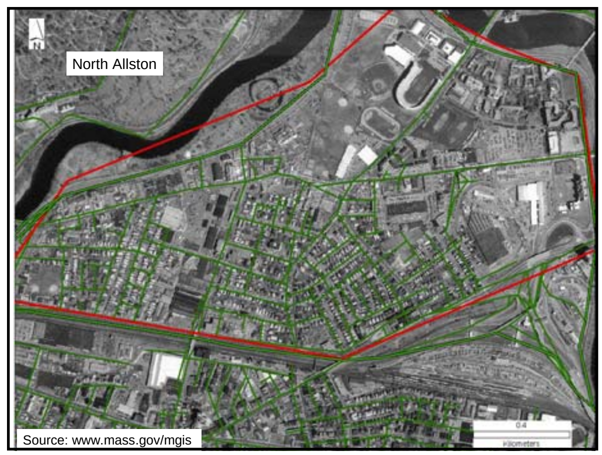
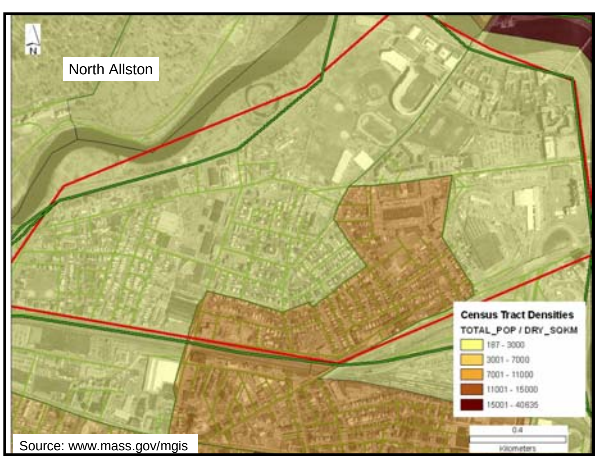

North Allston
0.4
Kilometers
Source: www.mass.gov/mgis


North Allston
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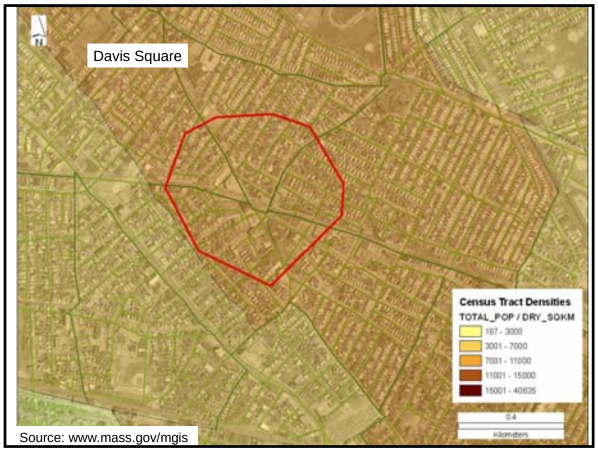
15001 - 40635
0.4
Kilometers
Source: www.mass.gov/mgis


Davis Square
0.4
Kilometers
Source: www.mass.gov/mgis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Census Tract Densities
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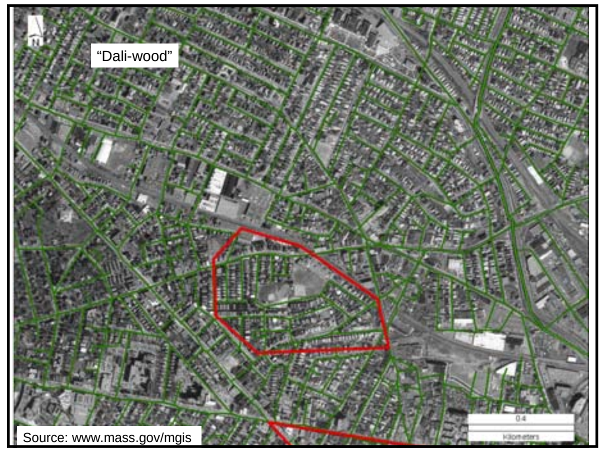
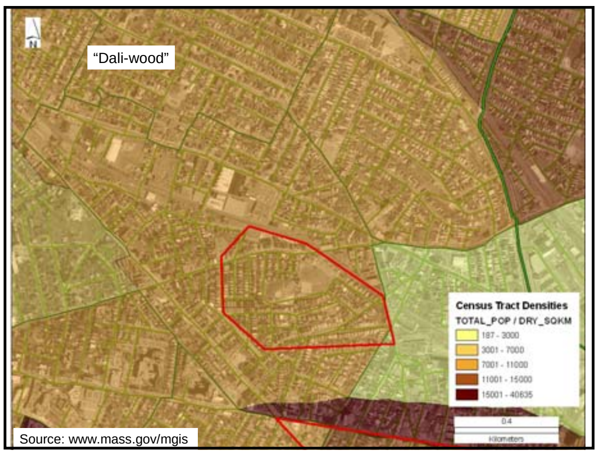

“Dali-wood”
Source: www.mass.gov/mgis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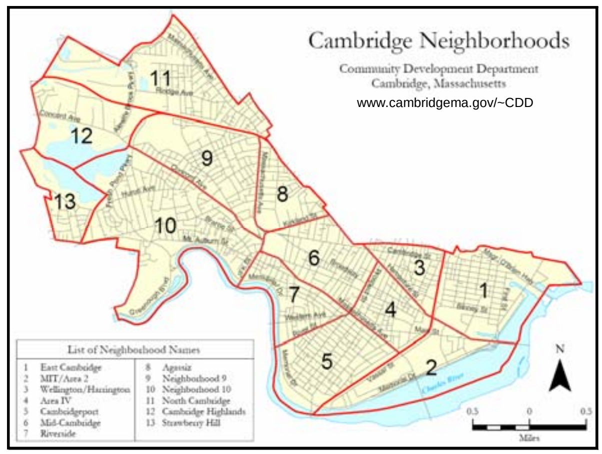
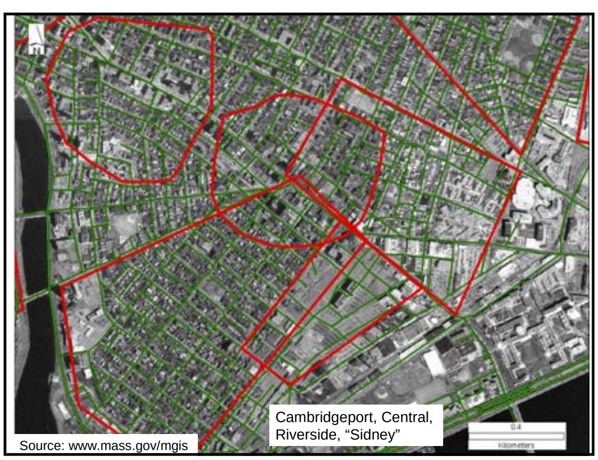
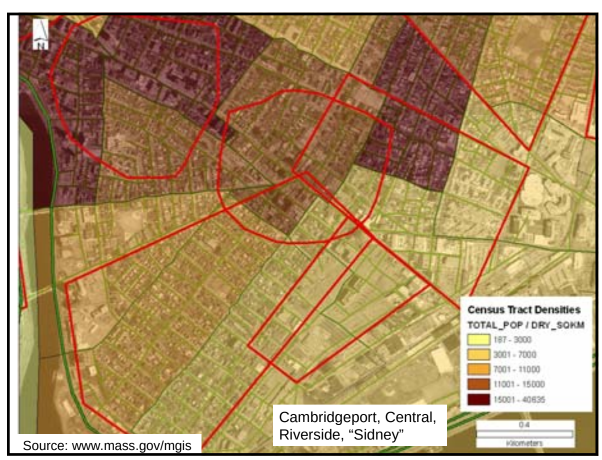

Cambridge Neighborhoods
Community Development Department
Cambridge, Massachusetts
www.cambridgema.gov/~CDD
List of Neighborhood Names
1 East Cambridge
2 MIT/Area 2
3 Wellington/Harrington
4 Area IV
5 Cambridgeport
6 Mid-Cambridge
7 Riverside
8 Agassiz
9 Neighborhood 9
10 Neighborhood 10
11 North Cambridge
12 Cambridge Highlands
13 Strawberry Hill
Miles


Cambridgeport, Central, Riverside, “Sidney”
Source: www.mass.gov/mgis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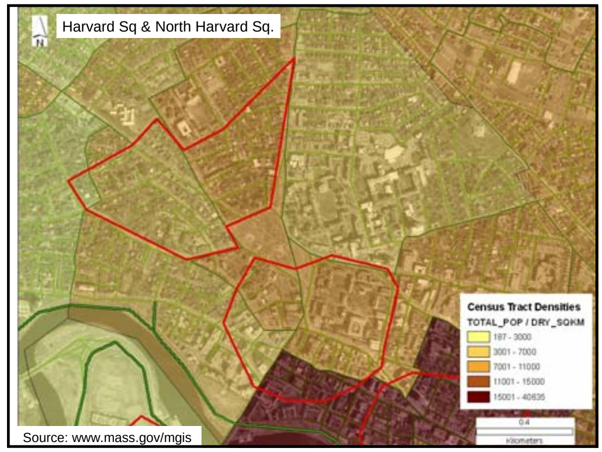
Harvard Sq & North Harvard Sq.
Source: www.mass.gov/mgis


Harvard Sq & North Harvard Sq.
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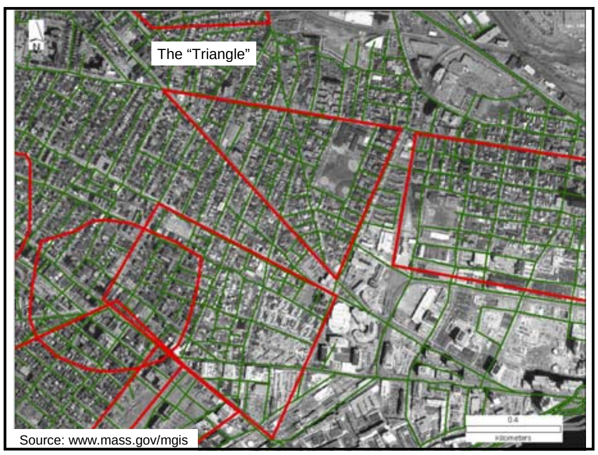
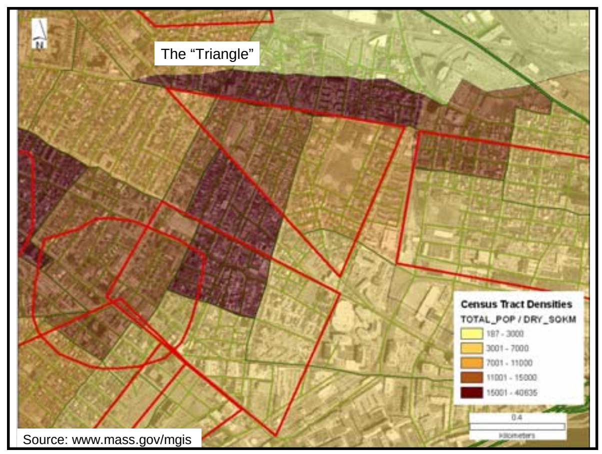

The "Triangle"
Source: www.mass.gov/mgis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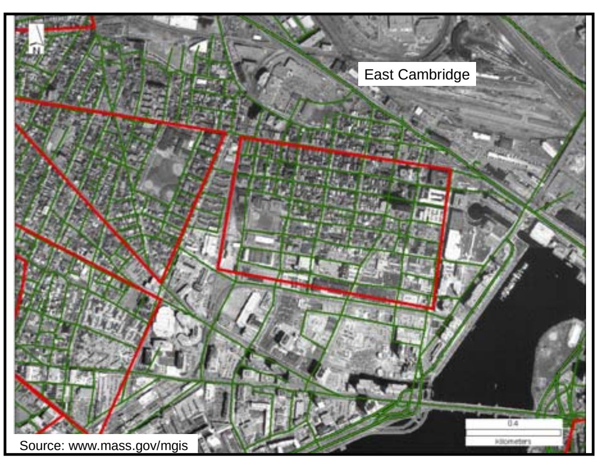
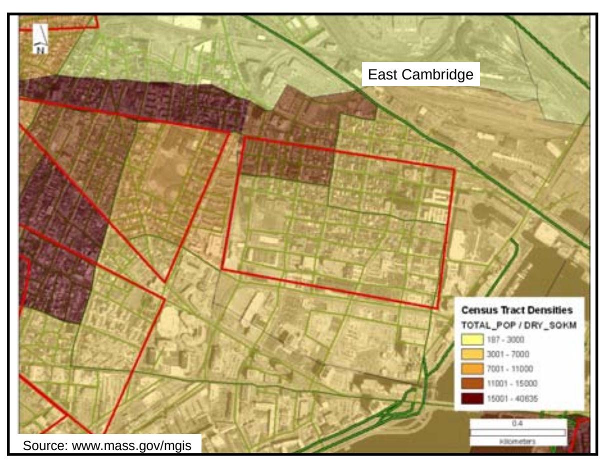

East Cambridge
Source: www.mass.gov/mgis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Physical Characteristics of "Relevance"

- "Neighborhood"
  - Parking, Transit Access
  - Traffic Calming
  - Density
  - Street Width, Streetscape, NMT Networks, Mix Uses
- Regional Setting, Access to Jobs

Non-Physical Characteristics & Future Factors

Non-Physical Characteristics

- Student populations
- Family Life-cycle
- Vehicle Costs

Future Factors

- Public Transport Networks
- Automobile Costs
- "Culture"

Accessibility

Defining Accessibility

- "extent to which the land-use and transportation systems enable (groups of) individuals to reach activities or destinations"
  (Geurs and van Wee, 2004; p. 128)

Accessibility = Function of:

(transportation system, land use patterns, the individual characteristics of firms and people, the overall quality of "opportunities" available, the communications system)

Accessibility: Contributing Elements

Elements	Effect on Accessibility (all else equal)
Transportation	Improved with more links, faster or cheaper service
Spatial distribution of "opportunities"	Improved if proximity of opportunities is increased
Individual (personal/firm) characteristics	Improved with physical, mental, economic ability to take advantage of opportunities
Quality of opportunities	Improved with more, or better, opportunities within same distance/time

Derived from BTS, 1997

Accessibility and Human Development

Sen's (2002) view of sustainable development:

"***enhancing human freedoms on a sustainable basis"***

Sen's Concept	Meaning	Link to Accessibility/Mobility
Functionings	Everything that an individual may wish to be or do (to "flourish" as human beings)	Potential trip purposes (work, school, shopping, etc.)
Capabilities	Freedom to achieve the "functionings" that individuals have reason to choose	The land use-transportation system directly influences an individual's ability to realize trip purposes and combinations of trip purposes

Inspired by Sen (1998)

Types of Accessibility Measures

Measure Type	Examples	Suitability
Infrastr.-based	Travel speeds by different modes; operating costs; congestion levels	Weak - only reflect level of throughput, no explicit land-use component
Location-based	Distance measures (e.g., cumulative opportunities); potential measures (e.g, gravity-based measures)	Okay/Good - normally derived for some spatially aggregated unit; can represent stratified population segments
Person-based	Space-time prisms	Good - measured at the individual level, according to temporal constraints
Utility-based	Random utility-based measures (i.e., from discrete choice models or the doubly constrained entropy model)	Good - based on microeconomic benefit (utility) for individuals or stratified population segments

Geurs and van Wee, 2004.

Infrastructure-Based Example

- 60 Largest US MSAs
- "Representative" Points in counties chosen
- Point-to-point travel times calculated (based on existing road network and relevant average speeds
- Average calculated for each origin
- Average of averages calculated = Accessibility Index

Internal Accessibility Measures for the 60 Largest MSAs

MSA	Average travel time (minutes)	MSA	Average travel time (minutes)
Sacramento, CA	69.72	Cleveland, OH	48.32
Houston, TX	69.45	Indianapolis, IN	47.16
Phoenix, AZ	67.79	San Antonio, TX	46.86
Tulsa, OK	67.76	Allentown, PA	46.84
Dallas. TX	65.49	Kansas City, MO	46.63
Los Angeles, CA	62.53	Tampa, FL	46.62
Detroit, MI	62.00	Dayton, OH	46.59
Pittsburgh, PA	61.52	Buffalo, NY	46.41
Rochester, NY	60.42	Honolulu, HI	46.37
St. Louis, MO	59.43	Orlando, FL	46.05
San Diego, CA	58.24	Ft. Lauderdale, FL	45.76
Greensboro, NC	57.73	Cincinnati, OH	45.50
Denver, CO	57.42	Toledo, OH	45.39
Nashville, TN	57.18	Columbus, OH	44.51
Birmingham, AL	56.71	Seattle, WA	44.45
Miami, FL	56.59	San Francisco, CA	42.46
Atlanta, GA	56.19	Louisville, KY	42.26
New York, NY	55.23	Charlotte, NC	40.09
Minneapolis, MN	55.08	Richmond, VA	40.50
Hartford, CT	54.97	Philadelphia, PA	40.17
Syracuse, NY	54.88	Milwaukee, WI	39.53
Albany, NY	54.14	New Orleans, LA	39.39
Providence, RI	52.95	Baltimore, MD	36.64
Chicago, IL	52.72	San Jose, CA	35.92
Oklahoma City, OK	51.42	Youngstown, OH	34.87
Salt Lake City, UT	50.95	Gary, IN	34.33
Memphis, TN	50.49	Anaheim, CA	34.16
Boston, MA	50.17	Grand Rapids, MI	32.97
Portland, OR	49.44	Newark, NJ	30.46
Washington, DC	48.68	Akron, OH	30.00

Allen et al, 1993; BTS, 1997.

Gravity-based Measures

- Theoretical origins in physics,
- Improvement over distance-based measures, partly because they attempt to better reflect travel behavior realities through their functional form, generally:

$$A_i = \sum_j W_j f(c_{ij}, \beta)$$

- where:
  - W_j represents the opportunities available in a given zone j;
  - $f(c_{ij}, \beta) = \exp(-\beta c_{ij})$ = impedance between zones i and j;
  - c_{ij} represents the travel cost/distance between zones i and j; and
  - β is a travel cost sensitivity parameter.
    - generally enters as a negative exponential function
    - the accessibility measure clearly is highly sensitive to this parameter.
    - Should come from empirical analysis

Gravity-based Measures

- Can be derived for an area (zone) and/or groups of people
- Fairly straightforward calculation based on readily available data
- Can be adapted to account for competition for opportunities at the destination
  - e.g., when the number of job opportunities is limited at given site (Shen, 1998)

"Person-based" or "Constraints-based"

- Origins in Hagerstrand's (1970) time-space framework
  - aims to capture temporal and spatial constraints
  - i.e., both distance (between themselves and potential activities) *and* available time (to engage in activities).
- Theoretically appealing
- Some applications
- Data-intensive
  - e.g., require information on people's activities and time budgets
- Computationally burdensome

Baradaran and Ramjerdi, 2001

Utility-Based Accessibility

- Can reflect individual preferences
  - Consistent with Sen's "human freedoms" perspective
  - Based on the individual's *actual* choice set
- Directly linked to traditional measures of consumer surplus
  - Based in microeconomic theory (Williams, 1977; Small and Rosen, 1981)
- Derived from discrete choice models
  - With a long tradition of application in transportation system analyses

Utility-Based Accessibility: the Logit Model

$$U_{jn} = V(z_{jn}, s_n, \beta) + \varepsilon_{jn}$$

$$P_n(i) = \frac{e^{\mu V_{in}}}{\sum_{j=1}^{j} e^{\mu V_{jn}}}$$

Utility-Based Accessibility: The "Logsum" and Nested Logit

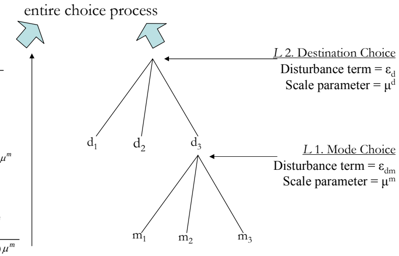
$$P_n(dm) = P_n(m \mid d) P_n(d)$$

"Logsum" at "the root" represents composite benefit ("Expected Maximum Utility") of the entire choice process

$$P_n(d) = \frac{e^{(V_d + V'_d)\mu^d}}{\sum_{d \in D_n} e^{(V_d + V'_d)\mu^d}}$$

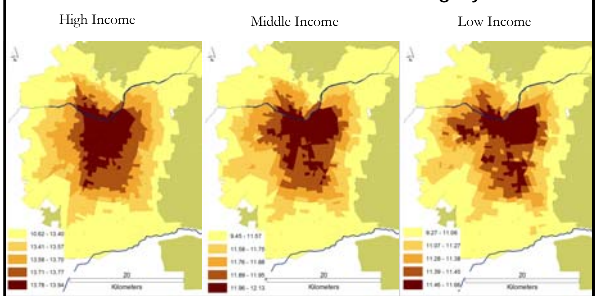
$$V'_d = \frac{1}{\mu^m} \ln \sum_{m \in M_{nd}} e^{(V_m + V_{dm})\mu^m}$$

$$P_n(m \mid d) = \frac{e^{(V_m + V_{dm})\mu^m}}{\sum_{m \in M_{nd}} e^{(V_m + V_{dm})\mu^m}}$$



Social Accessibility Levels

Female Adult, Evaluated at Mean Relevant Characteristics for Income Category



Social Accessibility Levels

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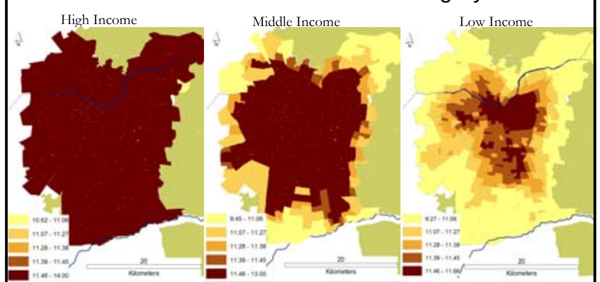
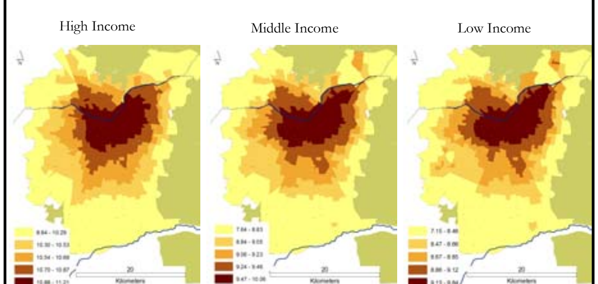


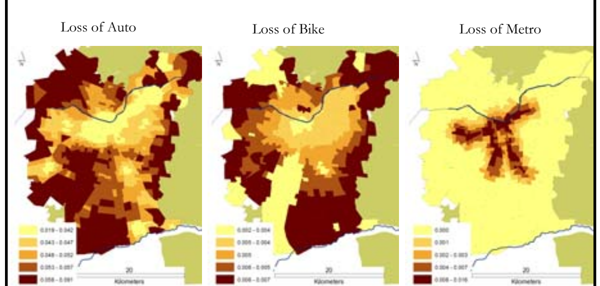
Recreational Accessibility Levels

Male Adult, Evaluated at Mean Relevant Characteristics for Income Category



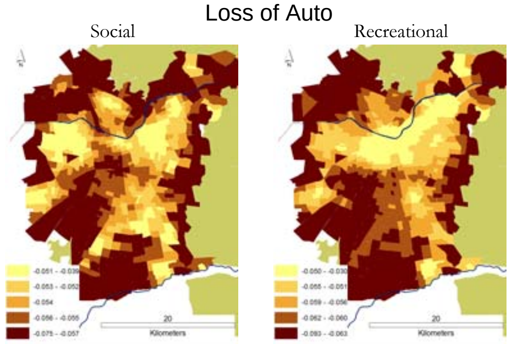
Relative Decline in Recreational Accessibility

Middle Income Female



Average Relative Decline in Female Accessibility

Loss of Auto



"Utility-based" Measures

- Theoretically appealing
  - Basis in behavioral theory and welfare economics
- Not immediately and easily convertible into meaningful and understandable units
  - Convertible into currency, time, but cumbersome
- Assumes utility linear with respect to income
  - Nonpresence of income effect
- Still *travel-biased* measures
  - Cannot immediately account for non trip-based accessibility (e.g., not traveling; trip-chaining)