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An Activity-related Land Use Mix Construct and Its Connection to Pedestrian Travel

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Research context

Sustained popularity toward investigating transportation-land use interactions

- Prospect to moderate travel behavior by physically altering our urban landscape

Increased adoption of policies focused on land use mixing

- Smart growth communities and mixed use developments
- Improve BE efficiencies increase local accessibility and encourage walking

Research interest

Multidisciplinary interest

- Reduce auto-related travel behaviors, balance travel demand, promote tour complexity
- Promote urban revitalization, slow rural land consumption, increase visible interest
- Higher rates of physical activity, reduced vehicle emissions, mental health benefits

Remains a goal without an established set of indicators

- Variety of metrics evaluating effectiveness of programs or policies in relation to travel
- Misguidance of practice by adoption of measures with imperfect theoretical foundations

Land use mix measurement

Accessibility

Ease of an individual to reach an opportunity from a location

Theorized link to travel

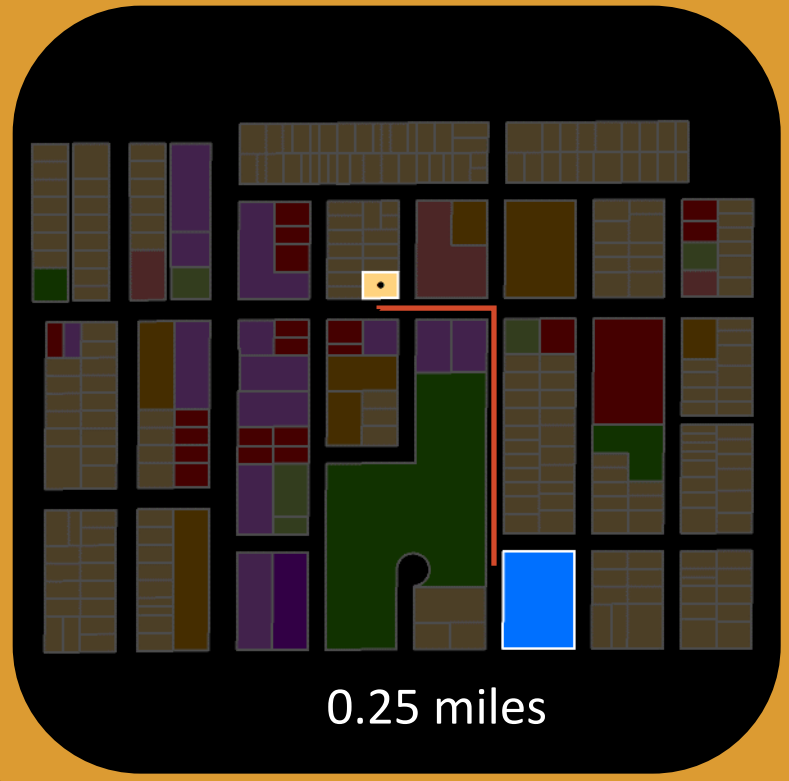
Reduced distance between locations increases feasibility of walking by diminishing competitive edge of faster modes

Shortcomings

- Only measures distance between two activity locations
- Provides summary calculation for only the origin

Accessibility Measures

- **Distance-based**



Land use mix measurement

Intensity

Count of locations or percent of area related to land use type

Theorized link to travel

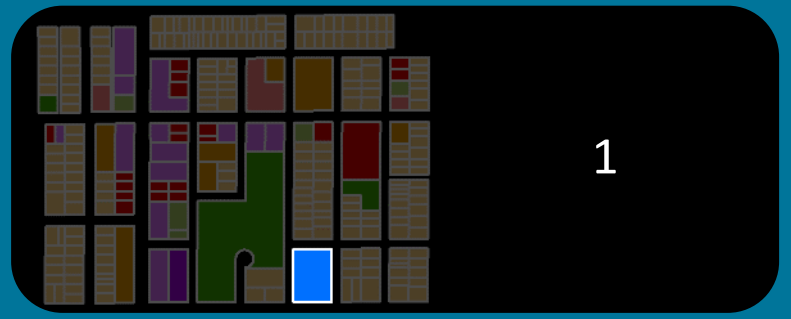
Increased intensity of activity locations enhances practicality of walking to fulfill a variety of daily life activities

Shortcomings

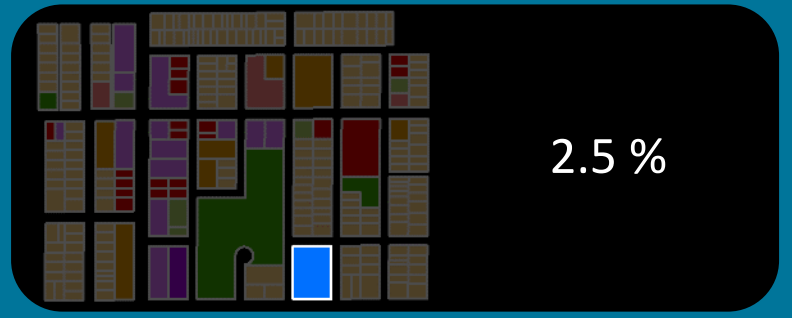
- Inability to summarize intensity of multiple land use types
- Sensitive to chosen spatial extent for operationalization

Intensity Measures

- **Count-based**



- **Percent-based**



Land use mix measurement

Pattern

Level of integration among different land use types in an area

Theorized link to travel

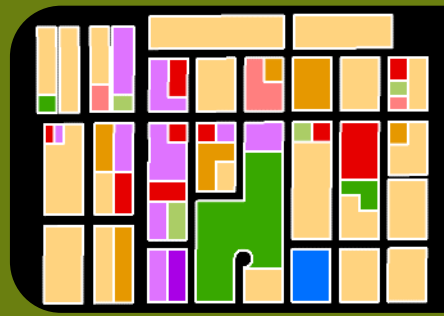
Mix of residential and nonresidential land uses encourages internal walking trips in place of potential external auto trips

Shortcomings

- Entropy indices have perfect balance assumption
- Limited consideration of functional complementarity
- Concentration on non-spatial composition measures
- Variety in adoption of land use typologies

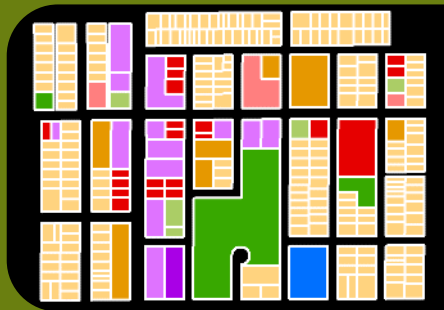
Pattern Measures

- **Composition**



Entropy
0.73

- **Configuration**



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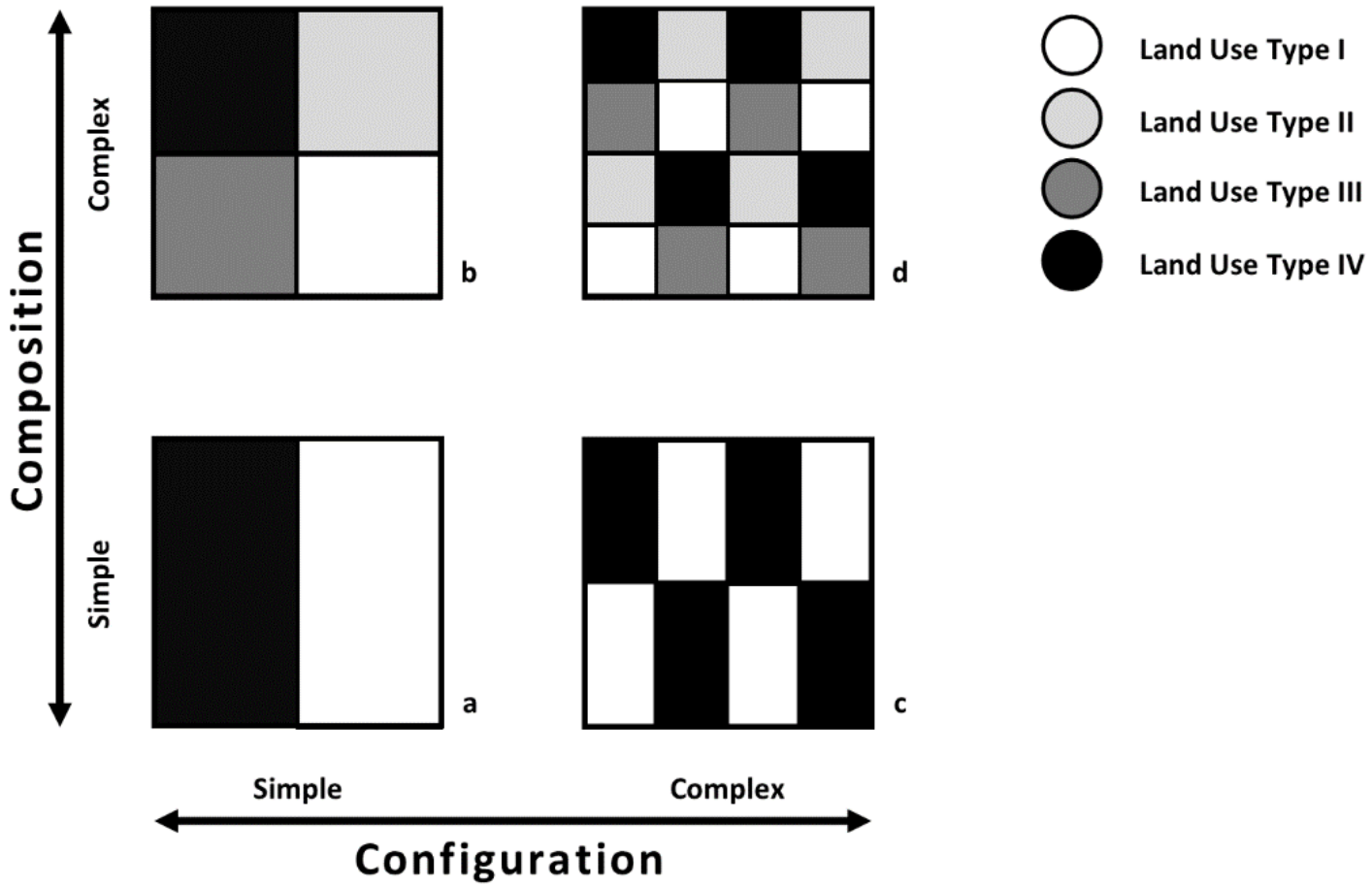
Land use composition and configuration



Pattern in landscape ecology research

- Richness
- Proportion
- Diversity
- Evenness

- Patch Size / Shape
- Isolation / Proximity
- Contagion / Interspersion
- Connectivity

Study objectives

1. Introduce land use mix measure reflecting construct's multidimensionality
   - Quantify the composition, configuration, and complementarity of local land use types
   - Explore the impact of geographic scale on land use mix measurement

2. Demonstrate connection between mix construct and pedestrian travel
   - Examine impact of mix on trip-level walk mode choice and home-based walk frequency
   - Compare effect of land use mix construct to effect of entropy and other BE measures

Study area & data sources

Land use

- Parcel-level data from local jurisdictions
  - Study area contained 904,398 parcels
  - Disaggregated to 65,312,000 66-ft grid cells
- Additional data from secondary sources
  - Density: 2010 US Census and 2011 LEHD
  - Design: 2011 TIGER files

Transportation

- 2009-11 OR Household Travel and Activity Survey
  - Info on 8,725 households, 14,264 adults, & 64,060 trips
  - Walking feasible (≤ 2 miles) for 29,198 trips
  - Walk mode chosen for 15% of trips (n = 4,344)

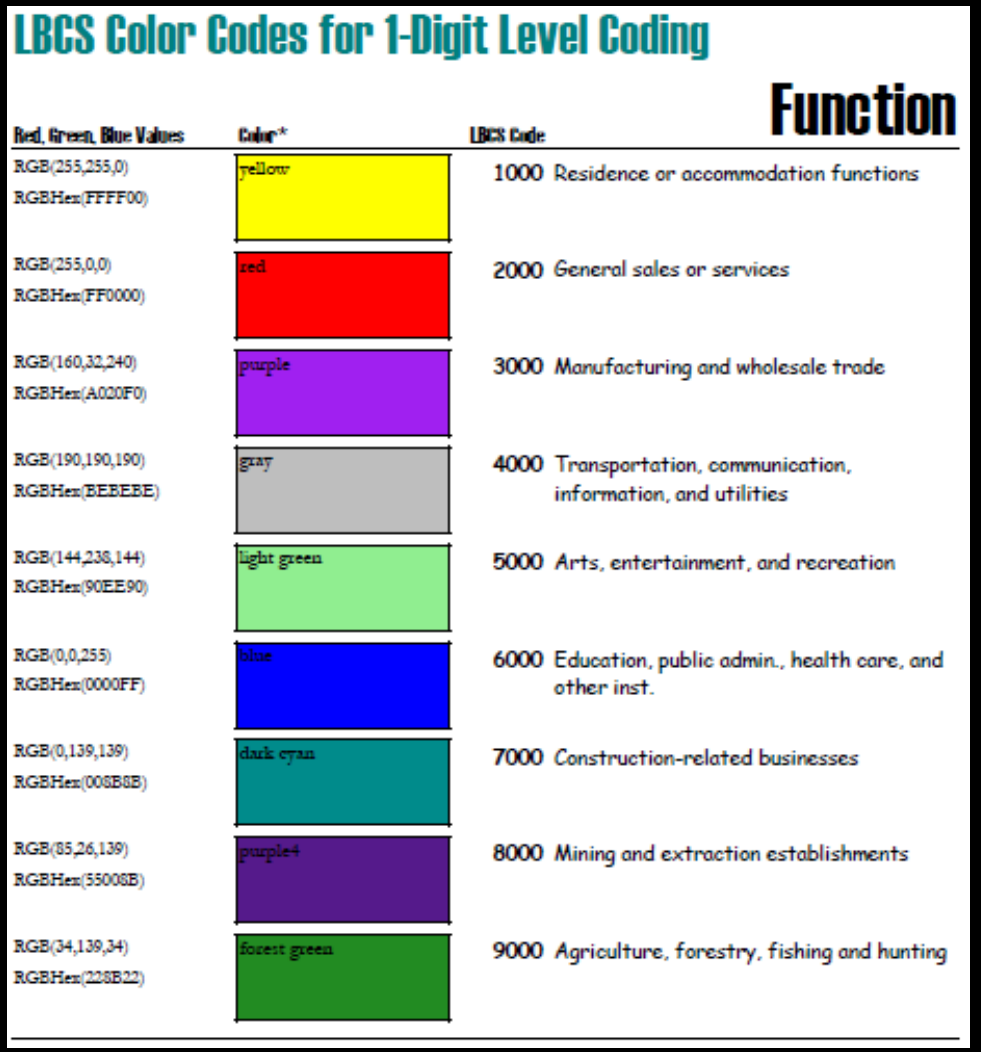
Analytic plan

Land Use Mix Measurement

- APA Land-based Classification Standards (Function)
- Operationalize indicators at artificial fixed grids
  - 1.00-mile grid: 10,250 cells
  - 0.50-mile grid: 40,820 cells
  - 0.25-mile grid: 163,280 cells
- Confirmatory Factor Analysis
- Assign predicted factor scores to grid cells

Connection to Pedestrian Travel

- Estimate impact of mix on walk mode and trip count
- Compare land use mix construct to entropy index and other BE determinants of walking behaviors



Land Use Mix Measurement

- **Residential and Retail Patch Richness** — λ Range: 0.62 to 0.67
- **Activity-related Complementarity** — λ Range: 0.85 to 0.89
- **Maximum Patch Size** — λ Range: -0.92 to -0.92
- **Contagion Index** — λ Range: -0.96 to -0.96

CFA Model Summaries

M1: Quarter-Mile Grids

CFI:	0.99
RMSEA:	0.02

M2: Half-Mile Grids

CFI:	0.99
RMSEA:	0.06

M3: One Mile Grids

CFI:	0.99
RMSEA:	0.09

Land use mix construct

+ 3 SD

2 - 3 SD

0 - 1 SD

1 - 2 SD

Connection to Pedestrian Travel

- Age
- Education
- Gender
- Household children
- Household income
- Household vehicles

- Population density
- Employment density
- City block centroids
- Connected node ratio
- Land use entropy
- Land use mix construct

Other Contextual Factors

- Trip distance

Walk Mode Choice

	0.25 mile		0.50 mile		1.00 mile	
Age	--	--	--	--	--	--
Education	+	+	+	+	+	+
Female	--	--	--	--	--	--
Household children	--	--	--	--	--	--
Household income	+	+	+	+	+	+
Household vehicles	--	--	--	--	--	--
Trip distance	--	--	--	--	--	--
Land use entropy	NS		NS		NS	
Land use mix construct		+		+		+

Walk Trip Frequency

	0.25 mile	0.50 mile	1.00 mile
Education	--	--	--
Household children	+	+	+
Household vehicles	--	--	--
Population density	NS	NS	NS
Employment density	NS	NS	+
City block centroids	+	+	+
Connected node ratio	+	+	+
Land use mix construct	+	+	+

* Age, household income, and gender were not statistically significant

Conclusions

Study Findings

- Improved land use mix measurement
  - Multidimensional construct described by intensity, composition, and configuration
  - Activity-related complementarity indicator moves beyond equal balance assumption
- Demonstrated link to pedestrian travel
  - Construct was stronger predictor of decision to walk than entropy measure
  - Construct was also significant predictor of home-based walk trip frequency

Next Steps

- SEM framework for retention of construct in measurement model
- Further attention to choice of geographic scale used to operationalize construct
- Transferability to states with weaker growth management policies

Thank you. Questions?

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Bonus Slides

Activity-related Complementarity

Pattern Measure of Land Use Composition

$$ARC = 1 - \sum_{i=1}^{n} \left[P_i \cdot \frac{|P_i - F_i|}{1 - F_i} \right]$$

Where,

P_i = Proportion of Land Use Type i

F_i = Activity Factor for Land Use Type i

Land Use Type	1000: Residence	2000: Sales	3000: Trade	4000: Transport	5000: Entertain	6000: Education	7000: Construct	8000: Extraction	9000: Agriculture
Activity Factor	0.41	0.31	0.03	0.01	0.01	0.17	0.00	0.00	0.06