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

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RESEARCH CONTEXT

- Sustained popularity for transportation-land use investigation because of a prospect to moderate travel behavior by physically altering landscapes
- Result is the adoption of land use mix policies that improve built environment efficiencies and increase the walkability of a neighborhood
- Many purported transport, land use, and health benefits have led to multidisciplinary interest
- However, land use mixing largely remains a goal without a definitive set of indicators to evaluate program effectiveness in relation to active travel

STUDY OBJECTIVES

- Introduce a land use mix measure reflecting the construct's multidimensionality
- Demonstrate the connection between this mix construct and pedestrian travel

STUDY DATA & SAMPLE

Table 1. Parcel distribution by APA's Land-Based Classification Standard

Code	Land Use Function	Parcels		Square Miles	
1000	Residence or accommodation	694,752	76.82%	306.48	3.24 %
2000	General sales or services	35,418	3.92 %	63.80	0.68 %
3000	Manufacturing and wholesale trade	11,339	1.25 %	94.83	1.00 %
4000	Transport, communication, utilities, etc.	2,425	0.27 %	69.17	0.73 %
5000	Arts, entertainment, and recreation	8,740	0.97 %	317.02	3.35 %
6000	Education, public admin., health care, etc.	14,630	1.62 %	273.73	2.90 %
7000	Construction-related businesses	1,211	0.13 %	1.39	0.01 %
8000	Mining and extraction establishments	194	0.02 %	15.89	0.17 %
9000	Agriculture, forestry, fishing and hunting	125,065	13.83 %	7,606.96	80.48 %
(none)	N/A	10,624	1.17 %	702.18	7.43 %
		904,398		9,451	

- Parcel data provided by local jurisdictions and disaggregated to 65,312,000 66-foot cells
- Additional secondary data from 2010 US Census, 2011 LEHD, and 2011 TIGER files

Table 2. Sample of households, adults, and person trips in study area

Oregon Counties	Households	Adults	Trip Ends	Survey Period
Clackamas, Multnomah, and Washington Counties	4,371	7,183	32,384	Apr-Dec 2011
Marion and Polk Counties	2,210	3,596	15,570	Mar-Jun 2010
Lane County	2,144	3,486	16,106	Aug-Dec 2009
	8,725	14,264	64,060	

- Transportation data provided by 2009-11 Oregon Household Travel and Activity Survey

CONNECTING MIX CONSTRUCT TO PEDESTRIAN TRAVEL

Table 3. Binary logistic model estimation results of trip-level walk mode choice (n = 29,198)

	One-Quarter Mile Grid				One-Half Mile Grid				One Mile Grid			
Independent Variables	**Model 1A**		**Model 1B**		**Model 2A**		**Model 2B**		**Model 3A**		**Model 3B**	
Respondent Age	negative		negative		negative		negative		negative		negative	
Respondent Education	positive		positive		positive		positive		positive		positive	
Respondent Female	negative		negative		negative		negative		negative		negative	
Household Children	negative		negative		negative		negative		negative		negative	
Household Income	positive		positive		positive		positive		positive		positive	
Household Vehicles	negative		negative		negative		negative		negative		negative	
Trip Distance	negative		negative		negative		negative		negative		negative	
	B (SE)	**Sig.**	**B (SE)**	**Sig.**	**B (SE)**	**Sig.**	**B (SE)**	**Sig.**	**B (SE)**	**Sig.**	**B (SE)**	**Sig.**
Land Use Mix Construct	**0.99 (0.12)**	***			**1.28 (0.14)**	***			**1.61 (0.15)**	***		
Land Use Entropy			-0.06 (0.13)	NS			0.02 (0.14)	NS			0.26 (0.14)	NS

Table 4. Negative binomial model estimation results of individual-level home-based trip counts (n = 13,386)

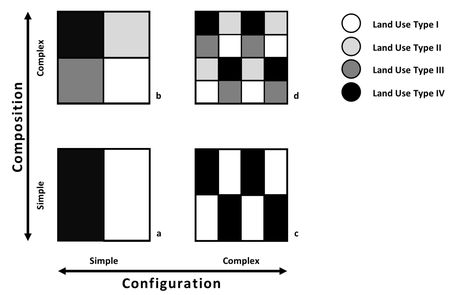
	One-Quarter Mile Grid		One-Half Mile Grid		One Mile Grid	
Independent Variables	**Model 4**		**Model 5**		**Model 6**	
Respondent Education	negative		negative		negative	
Household Children	positive		positive		positive	
Household Vehicles	negative		negative		negative	
	B (SE)	**Sig.**	**B (SE)**	**Sig.**	**B (SE)**	**Sig.**
Population Density	0.01 (0.00)	NS	0.01 (0.01)	NS	-0.01 (0.01)	NS
Employment Density	0.01 (0.00)	NS	0.01 (0.00)	NS	0.01 (0.00)	***
City Block Centroid	0.06 (0.01)	***	0.02 (0.00)	***	0.01 (0.00)	**
Connected Node Ratio	0.58 (0.12)	**	1.17 (0.32)	***	2.65 (0.48)	***
Land Use Mix Construct	**0.98 (0.21)**	***	**1.10 (0.22)**	***	**0.80 (0.22)**	***

MIX MEASUREMENT

Accessibility Measures
Ease of reaching an opportunity from an activity location or by individuals at that given location

Intensity Measures
Count of locations or percent of area related to a land use type within a landscape

Pattern Measures
Composition and spatial configuration of land use types within a landscape



MIX INDICATORS AND CONSTRUCT MEASUREMENT

Activity-related Land Use Complementarity
The balance of land use types based on derived travel rather than spatial equilibrium (composition measure)

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

F_i activity factors associated with land use type i
n number of land use types within the landscape

F_i = 1000: 0.41, 2000: 0.31, 3000: 0.03, 4000: 0.01, 5000: 0.01, 6000: 0.17, 7000: 0.01, 8000: 0.01, 9000: 0.06

Grid Size	Beta
Quarter-Mile:	0.85
Half-Mile:	0.87
One Mile:	0.89

Residential and Retail Patch Richness
The count of contiguous residential or retail land use patches within a landscape (intensity measure)

Quarter-Mile:	0.67
Half-Mile:	0.63
One Mile:	0.62

Maximum Patch Size
The largest area of adjoining parcels of a single land use type within a landscape (configuration measure)

Quarter-Mile:	- 0.92
Half-Mile:	- 0.92
One Mile:	- 0.92

Contagion Index
The interspersion and dissimilarity of adjacent pixels within a landscape (configuration measure)

$$1 + \frac{\sum_{i}^{n} \sum_{j}^{n} \left[(P_{ij}) \ln (P_{ij}) \right]}{2 \ln (n)}$$

P_{ij} probability that adjacent 66-foot grid cells belong to land use types i and j
n number of land use types within the landscape

Quarter-Mile:	- 0.96
Half-Mile:	- 0.96
One Mile:	- 0.96

CONCLUSIONS

- Introduced a multidimensional mix construct based on the composition, complementarity, and spatial configuration of local land use types
- Activity-related indicator redirects how planners measure an ideal compositional balance away from atheoretical equal balance assumption
- Mix construct explicitly accounts for the spatial arrangement of land use patches in a landscape
- Construct was a stronger predictor of decision to walk than the entropy index, and a significant determinant of home-based walk trip frequency

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NITC NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES