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Webinar: Transportation Benefits of Polycentric Urban Form

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Ewing, Reid and Sabouri, Sadegh, "Webinar: Transportation Benefits of Polycentric Urban Form" (2021). *TREC Webinar Series*. 50.
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GUIDELINES FOR A POLYCENTRIC REGION TO REDUCE VEHICLE USE AND INCREASE WALKING AND TRANSIT USE

PRESENTERS:

REID EWING AND SADEGH (SADI) SABOURI

DEPARTMENT OF CITY AND METROPOLITAN PLANNING

UNIVERSITY OF UTAH

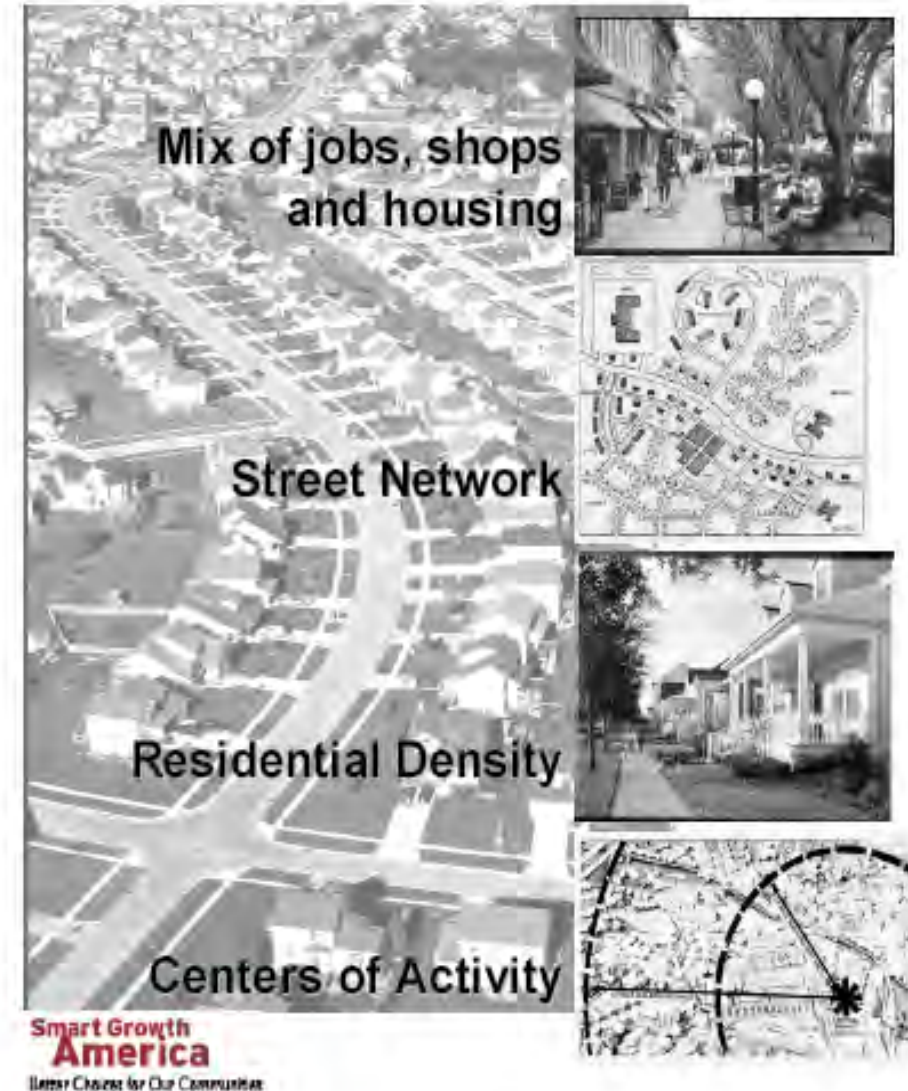
CO-AUTHORS: KEUNHYUN PARK, TORREY LYONS, KEUNTAE KIM, DONG-AH CHOI, KATHERINE DALY, ROYA ETMINANI GHASRODASHTI, FATEMEH KIANI, HASSAN AMELI, GUANG TIAN, DAVID GASPERS, AND JOHN HERSEY

MEASURING SPRAWL AND ITS IMPACTS

Released October 2002

MEASURING SPRAWL AND ITS IMPACT

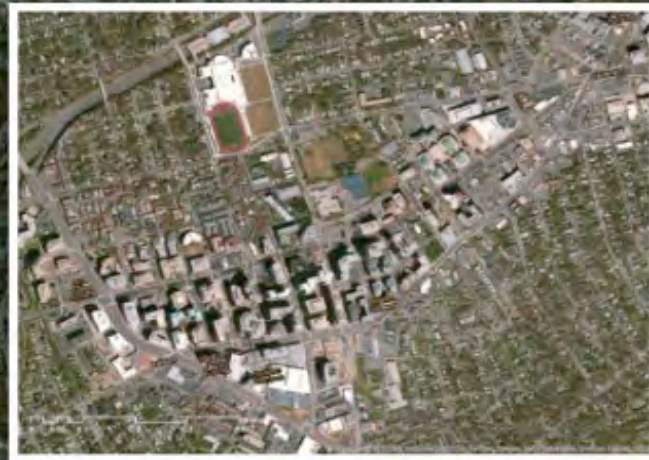
Reid Ewing, Rutgers University, Rolf Pendall, Cornell University, Don Chen, Smart Growth America



BROADER CONCEPTION OF SPRAWL

- Low Density
- Segregation of Uses
- Lack of Strong Centers
- Sparse Street Network

COSTS OF SPRAWL



Reid Ewing and Shima Hamidi

CONNECTIONS TO OUTCOMES

Physical activity, obesity (Ewing et al, 2003; Kelly-Schwartz et al, 2004; Sturm and Cohen, 2004; Doyle et al, 2006; Fan and Song, 2009; Plantinga and Bernell, 2007; Lee et al, 2009)

Traffic fatalities (Ewing et al, 2003)

Air quality (Kahn, 2006; Stone et al, 2010; Schweitzer and Zhou, 2010)

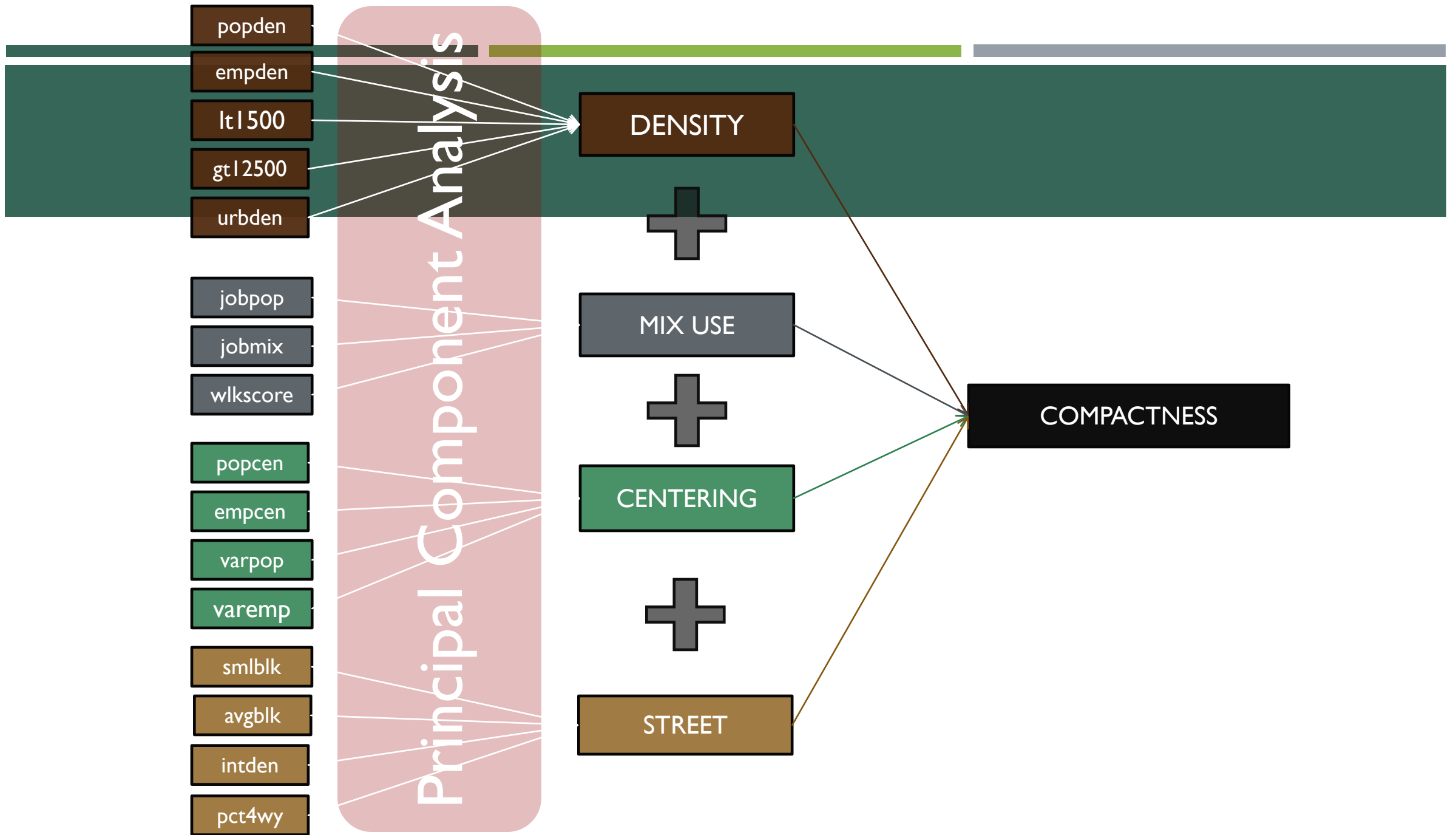
Residential energy use (Ewing and Rong, 2008)

Emergency response times (Trowbridge et al, 2009)

Teenage driving (Trowbridge and McDonald, 2008; McDonald and Trowbridge, 2009)

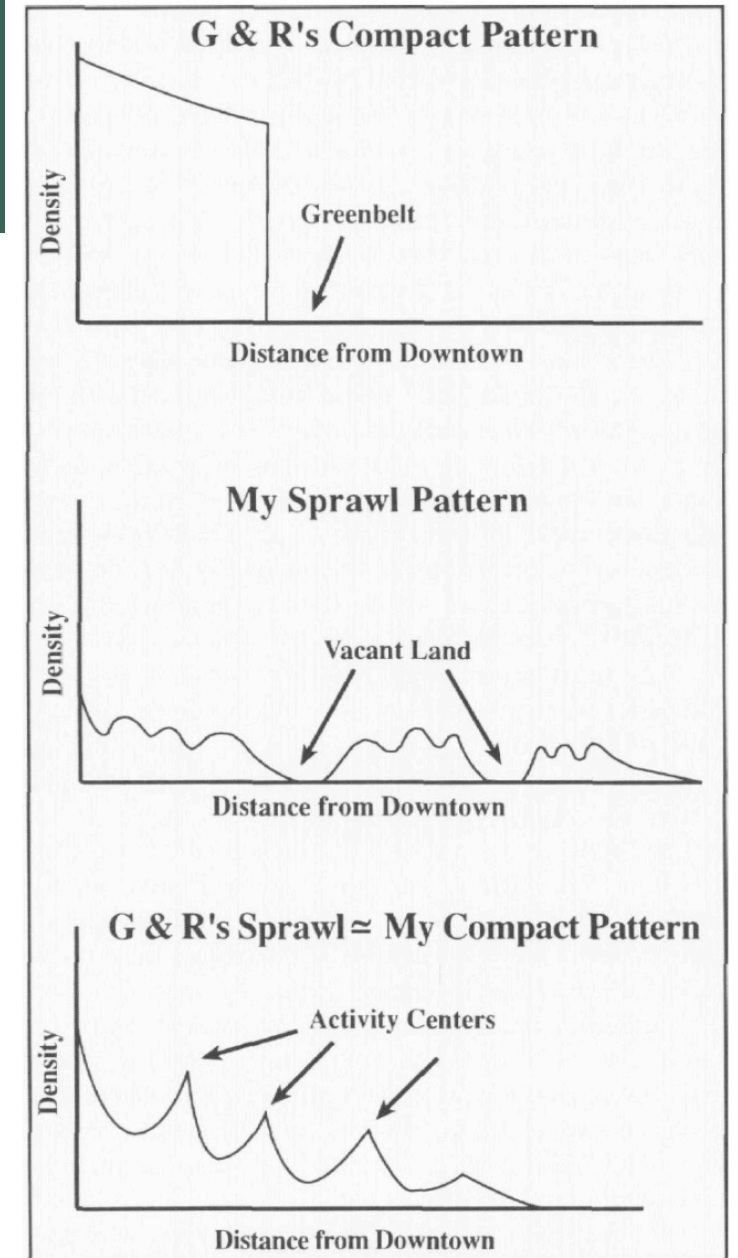
Social capital (Kim et al, 2006; Nguyen, 2010)

Private-vehicle commute distances and times (Ewing et al, 2003; Zolnik, 2011; Holcombe and Williams, 2012)



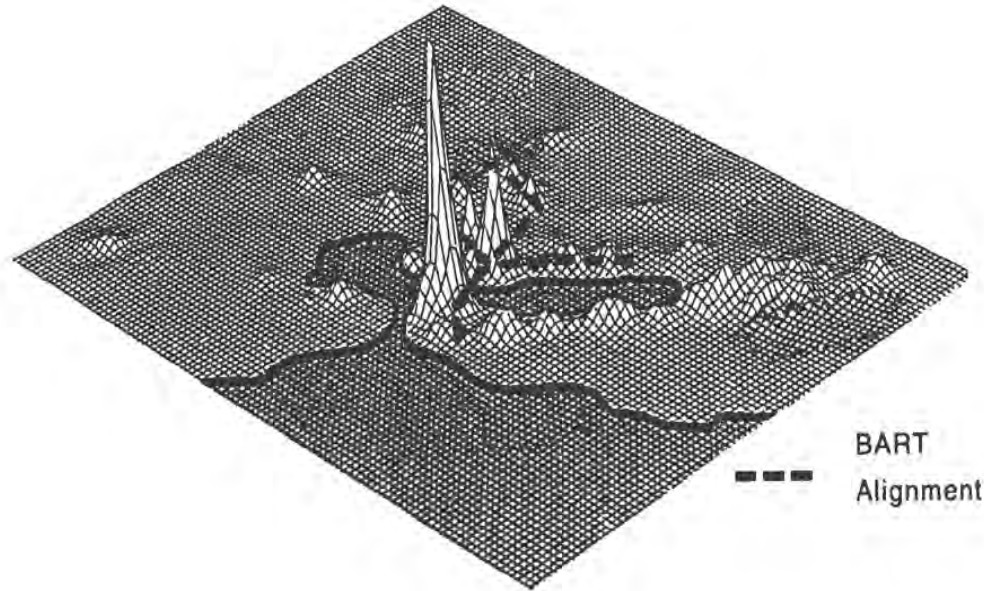
POLYCENTRICITY

- **Center:** “the densest parts of a region, characterized by compact and mixed-use development, well-connected by a multi-modal transportation network, and with more job opportunities than the areas around them.”
- **Polycentric development** is defined as a regional development pattern consisting of multiple centers that meet this definition.

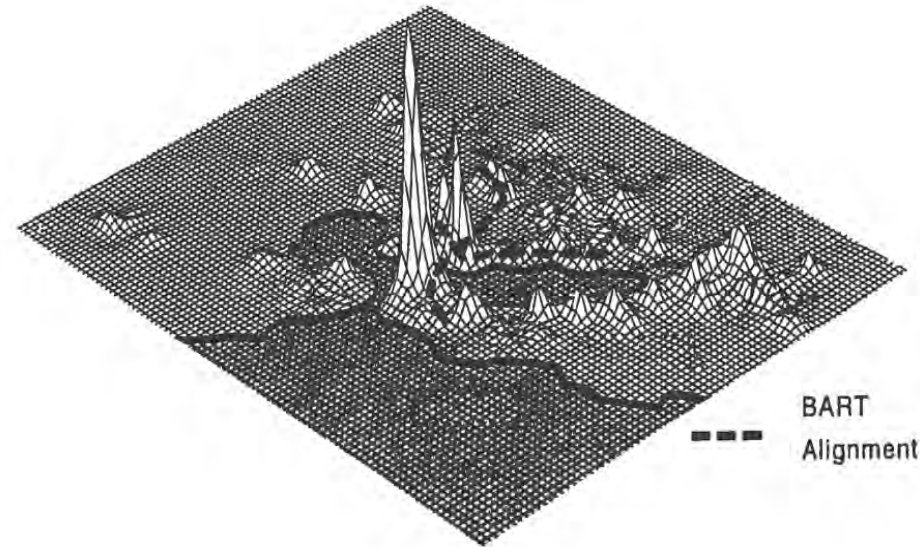


SUBCENTERING OF DEVELOPMENT

1980



BART
Alignment



BART
Alignment

1990

COMPACT DEVELOPMENT A LA U.S.



IN OUR FINAL NITC REPORT

- Review of the literature on polycentric development and trip chaining
- Examining polycentric development in regional transportation plans.
- Defining and Identifying Centers in 28 regions
- Quantifying the benefits of center development vs. uncenter development in terms of household travel
- Analyze trip chain (tour) inside centers, outside centers, and hybrid
- Qualitative Case Studies (Focusing on Portland).

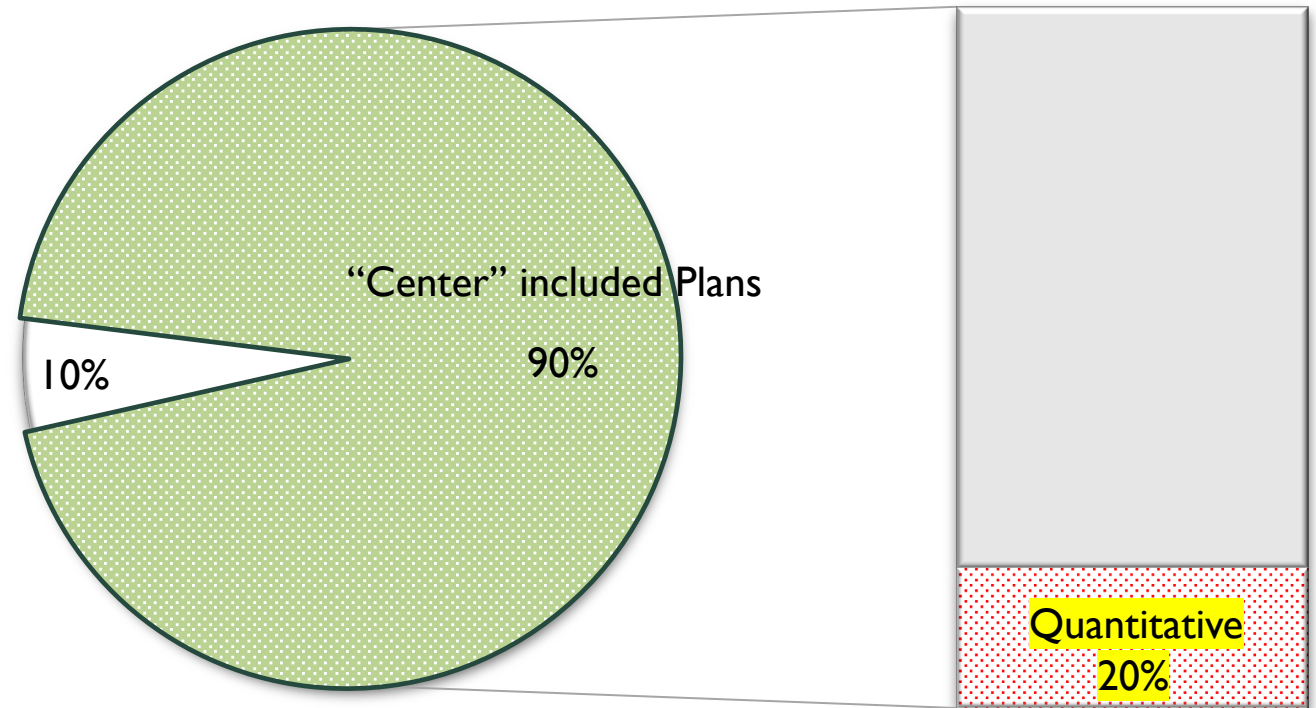
POLYCENTRIC DEVELOPMENT IN REGIONAL TRANSPORTATION PLANS

- Reviewed 126 regional transportation plans across the U.S. to check how centers are defined and proposed both qualitatively and quantitatively.

Center Type	Number of mentions	Center Type	Number of mentions
Activity Center	994	Metropolitan Center	30
Employment Center/ Industrial Employment Center	584	Industrial Center/Industrial Growth Center	29
Town Center	369	Neighborhood Activity Center	24
Urban Center/ Urban Growth Center	314	Community Activity Center	20
Regional center/Regional Core and Employment Corridor/ Metro Growth Center	186	Sub-regional business, civic, commercial and cultural centers	1
Major Activity Center	121	Suburban Employment Center	16
Community Center	116	Emerging Employment Center	10
City Center	89	Rural Village Activity Center	7
Major Employment Center	81	Community Commercial Center	2
Mixed Use Center	52	Center Planning Areas	2
Village Center	41	Government center	1
Suburban Center	31		

OBSERVATIONS FROM RTPs

- A center is described as the densest part of an area, characterized by compact and mixed-use development, multiple transit options, and employment opportunities
- Suffer from a lack of consistent indicators to designate centers and guide their developments
- Lacked criteria regarding minimum center densities and intensities of development; minimum population, employment, or land areas; target land-use mixes; and recommended transit service types or levels
- Only 20 percent of them get quantitative



Chattanooga, TN

Table 10.5 Recommended Development Standard

Development Centers	Density		Mixed-Use % (Open Space/ Res/Non-Res)	Building Design	Maximum Parking	
	Residential	Employment			Residential	Commercial
Regional Hub	20 – 50 DU/Acre	50 – 200 Jobs/Acre	5/30/65	3-5 FAR	1-1.5/DU	1-2/ksf
Community Activity Center	10 – 35 DU/Acre	20 – 65 Jobs/Acre	10/50/40	1-4 FAR	1.5-2/DU	2-3/ksf
Neighborhood Activity Center	7 – 12 DU/Acre	10 – 20 Jobs/Acre	15/70/15	0.5-1.5 FAR	2/DU	3/ksf
Growth Corridors	5 – 10 DU/Acre	5 – 15 Jobs/Acre	25/50/25	0.25-1 FAR	2-2.5/DU	3.5-3/ksf

Notes: DU = Dwelling Units, FAR = Floor Area Ratio, KSF = 1,000 Square Feet.

Table 10.6 Recommended Complete Street Standard

Development Centers	Intersection Density (No. of Intersection per Square Mile)	Bicycle Facility	Pedestrian Facility
Regional Hub	> 250	Cycle Track	10 – 16 feet
Community Activity Center	> 150	Bike Lane	6 – 12 feet
Neighborhood Activity Center	> 100	Multi-Use Path	Multi-Use Path
Growth Corridors	> 100	Bike Lane	6 – 10 feet

HOW CAN WE IDENTIFY CENTERS?

Multi-step criteria:

1. Find candidate central business districts (CBDs)

Clusters of high employment density based on Local Moran's I



2. Apply exclusion criteria

No more than 75 percent in any single employment sector



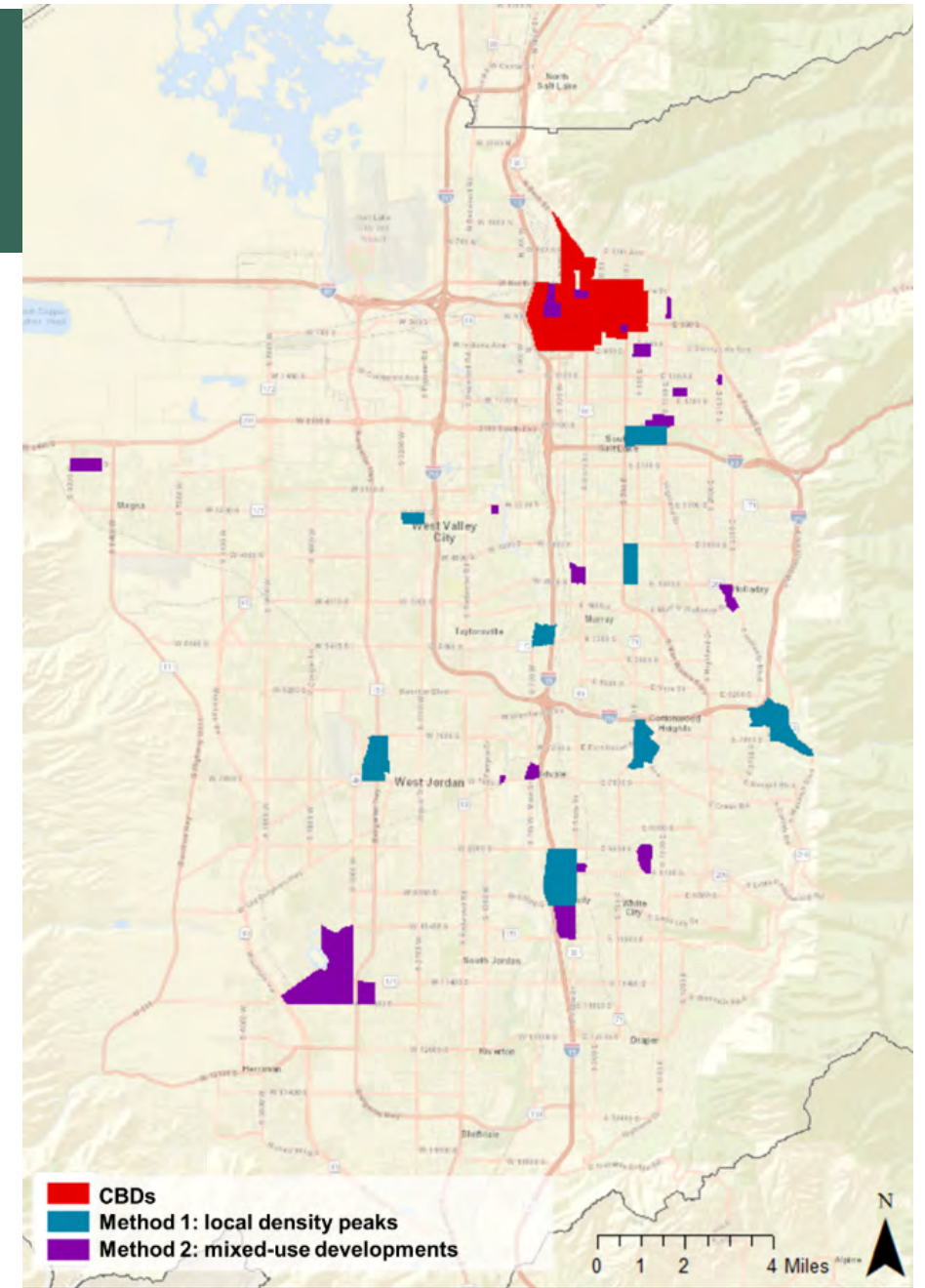
3. Identify potential employment subcenters

Clusters of high employment density that are far from CBDs based on Geographically Weighted Regression (Brunsdon et al., 1996)

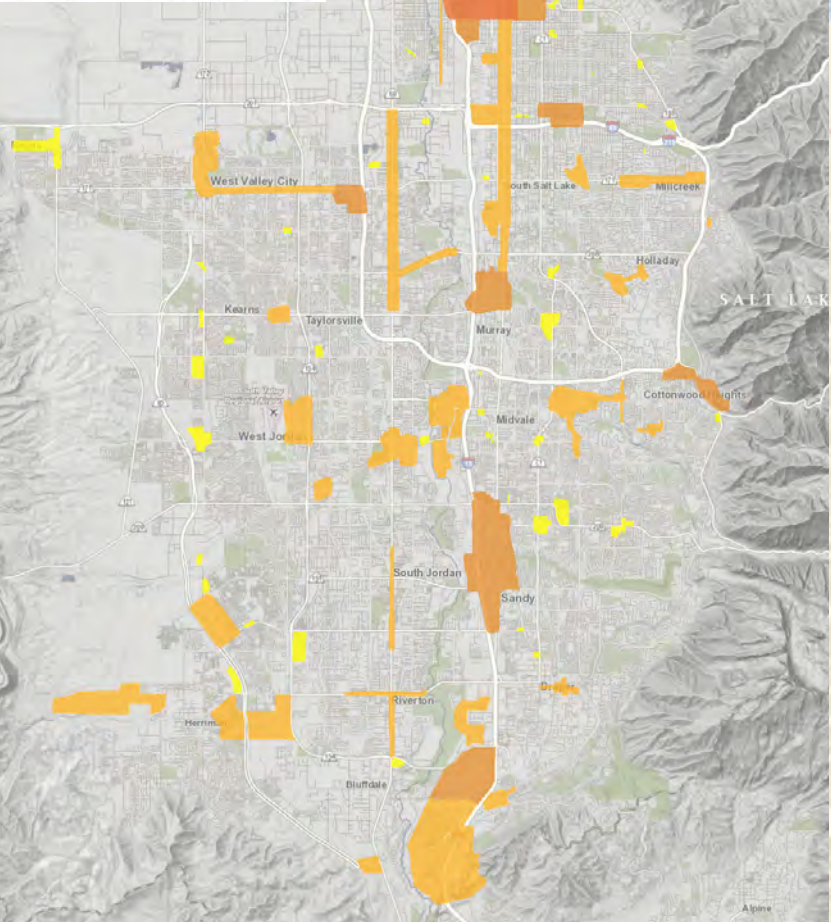


4. Validate result by WASATCH CHOICE 2050

589 centers identified in 28 U.S regions



Salt Lake County (Wasatch Choice 2050)



Salt Lake County (local employment density peaks)



Salt Lake County (mixed-use developments)

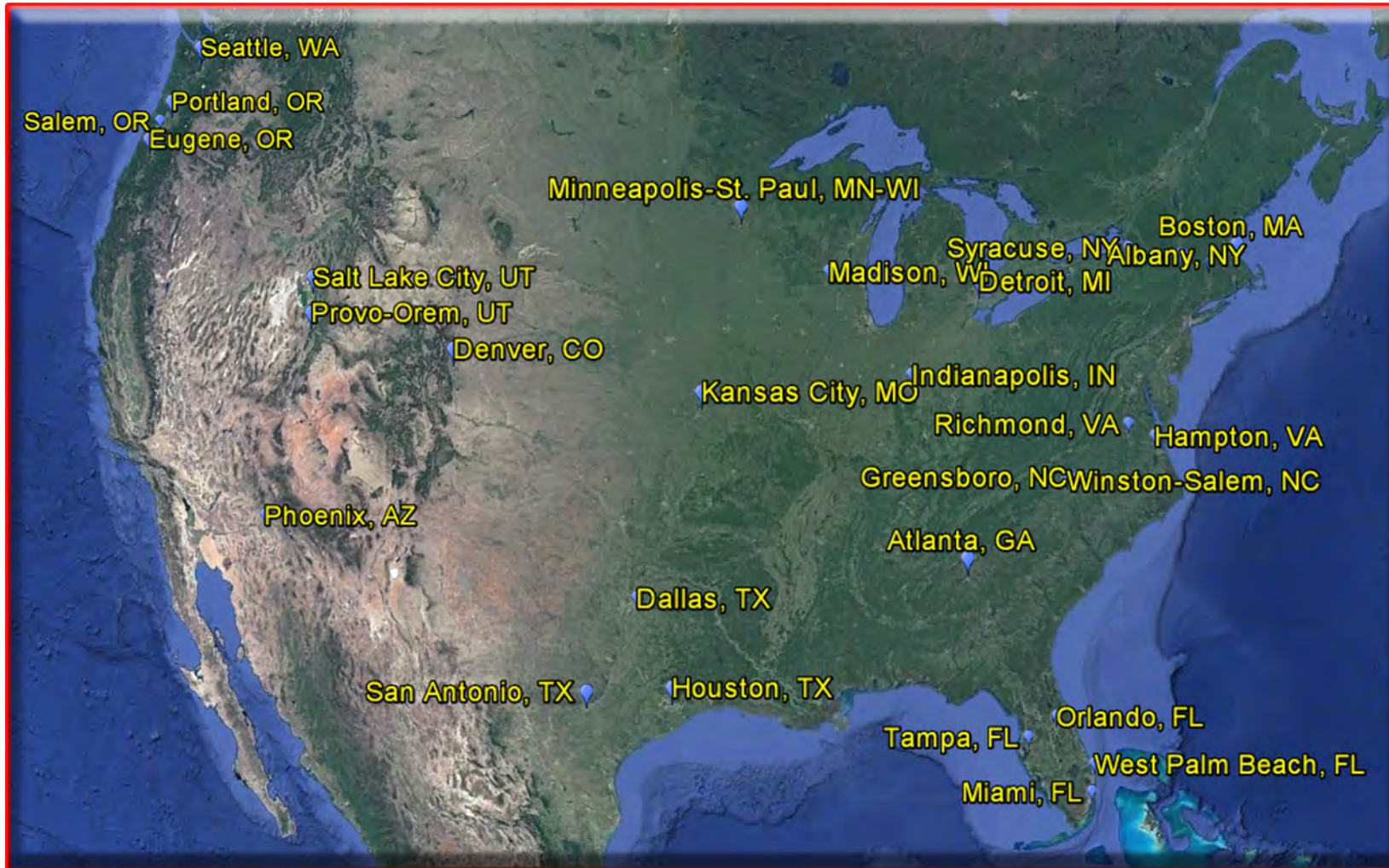


DATA AND METHODS

- This study identifies the location of CBDs and centers in 28 metropolitan regions of the U.S..
- For all 28 regions, we have collected regional household travel survey data from metropolitan planning organizations

Region	Survey year	Households in the survey	Number of centers	Trip ends (origins and destinations) within centers
Albany, NY	2009	1,447	30	4,940
Atlanta, GA	2011	9,574	17	7,980
Burlington, NC	2009	594	3	5,566
Dallas, TX	2009	2,869	15	16,682
Denver, CO	2010	5,551	42	15,408
Eugene, OR	2009	1,674	45	7,431
Greensboro, NC	2009	1,966	30	16,446
Hampton Roads–Norfolk, VA	2009	1,954	12	2,314
Houston, TX	2008	5,276	5	1,602
Indianapolis, IN	2009	3,777	50	19,570
Kansas City, KS-MO	2004	3,022	37	4,222
Madison, WI	2009	138	23	8,259
Miami, FL	2009	1,402	10	4,035
Minneapolis–St. Paul, MN-WI	2010	8,234	11	760
Orlando, FL	2009	866	29	1,932
Palm Beach, FL	2009	944	7	1,572
Phoenix, AZ	2008	4,314	3	2,428
Portland, OR	2011	4,509	2	1,157
Provo-Orem, UT	2012	1,464	5	2,927
Richmond, VA	2009	612	1	7,702
Rochester, NY	2011	3,438	13	852
Salem, OR	2010	1,668	12	926
Salt Lake City, UT	2012	3,490	33	2,124
San Antonio, TX	2007	1,563	76	4,902
Seattle, WA	2014	4,954	26	3,108
Syracuse, NY	2009	652	2	767
Tampa, FL	2009	2,259	6	179
Winston-Salem, NC	2009	1,459	44	17,696
Total		79,670	589	163,487

28 REGIONS



METHODS

- Identifying centers: CBDs and local density peaks
- Measuring travel outcomes and built environment variables
- Finding desirable values of D variables: Generalized Additive Model

D Variable	Description	Measurement in this study
Density	A variable of interest per unit of area. Population and employment are sometimes summed to compute an overall activity density.	Activity density= Sum of population and employment per square mile
Diversity	Diversity measures pertain to the number of different land uses in a given area and the degree to which they are balanced. Entropy measures of diversity, wherein low values indicate single-use environments and higher values more varied land uses, are widely used in travel studies. Jobs-to-housing or jobs-to-population ratios are also used.	<ol style="list-style-type: none"> 1. Job-population balance= $1 - \frac{[ABS(\text{employment} - 0.2 * \text{population})]}{(\text{employment} + 0.2 * \text{population})}$, where ABS is absolute value of expression in parentheses (Ewing et al., 2015). 2. Entropy index= $-\frac{[\text{residential share} * \ln(\text{residential share}) + \text{commercial share} * \ln(\text{commercial share}) + \text{public share} * \ln(\text{public share})]}{\ln(3)}$, where ln is the natural logarithm.
Design	Design measures include average block size, proportion of four-way intersections, and number of intersections per square mile. Design is also occasionally measured as sidewalk coverage, average building setbacks, or numbers of pedestrian facilities	<ol style="list-style-type: none"> 1. Intersection density = The number of intersections per square mile 2. Percentage of four-way intersection = the number of four-way intersections divided by the total number of intersections
Destination accessibility	Ease of access to trip attractions. Regional accessibility may be a distance to CBD or the number of jobs or other attractions reachable within a given travel time, which tends to be highest at central locations and lowest at peripheral ones.	<ol style="list-style-type: none"> 1. Percentage of regional employment within 10 minutes by car = % of jobs that can be reached within 10-minutes by automobile 2. Percentage of regional employment within 30 minutes by transit = % of jobs that can be reached within 30-minutes by transit
Distance to transit	Usually measured as the shortest street routes to the nearest rail station or bus stop. Alternatively, it may be measured as transit route density, distance between transit stops, or the number of stations per unit area.	Transit density = the number of stops per square mile

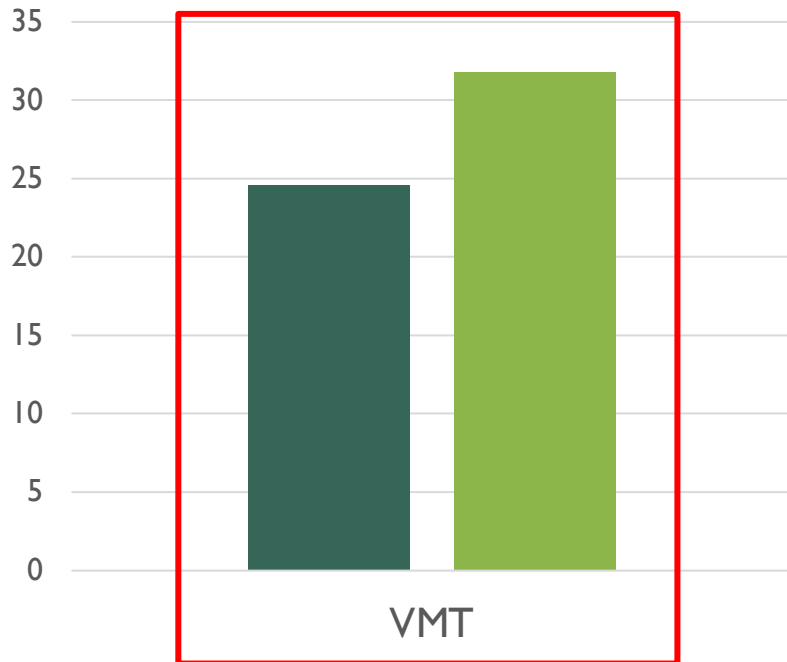
TRAVEL OUTCOMES WITHIN / OUTSIDE CENTERS

Data: Travel survey results from 28 U.S metropolitan regions

- 589 centers; 1,506 households within centers vs. 78,164 households outside centers

Travel outcomes comparison

■ Households living within a center
■ Households living outside a center

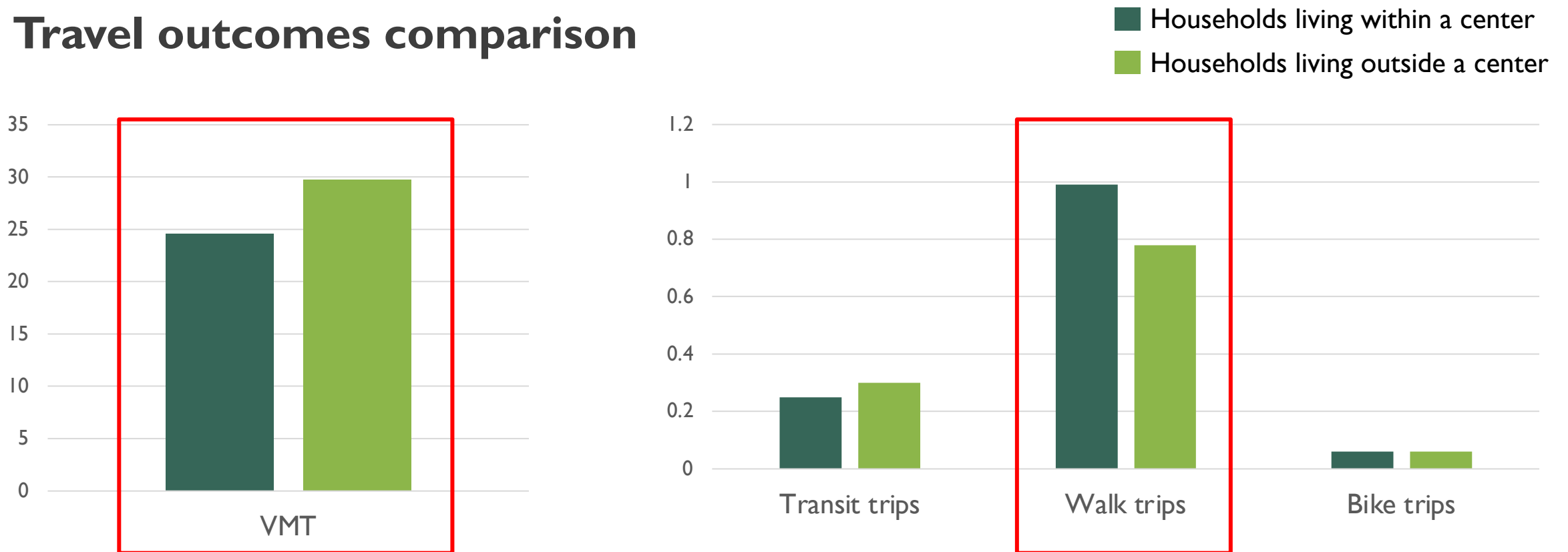


TRAVEL OUTCOMES WITHIN / OUTSIDE CENTERS BASED ON PROPENSITY SCORE MATCHING

Data: Travel survey results from 28 U.S metropolitan regions

- 589 centers; 1,498 households within centers vs. 1,498 households outside centers

Travel outcomes comparison

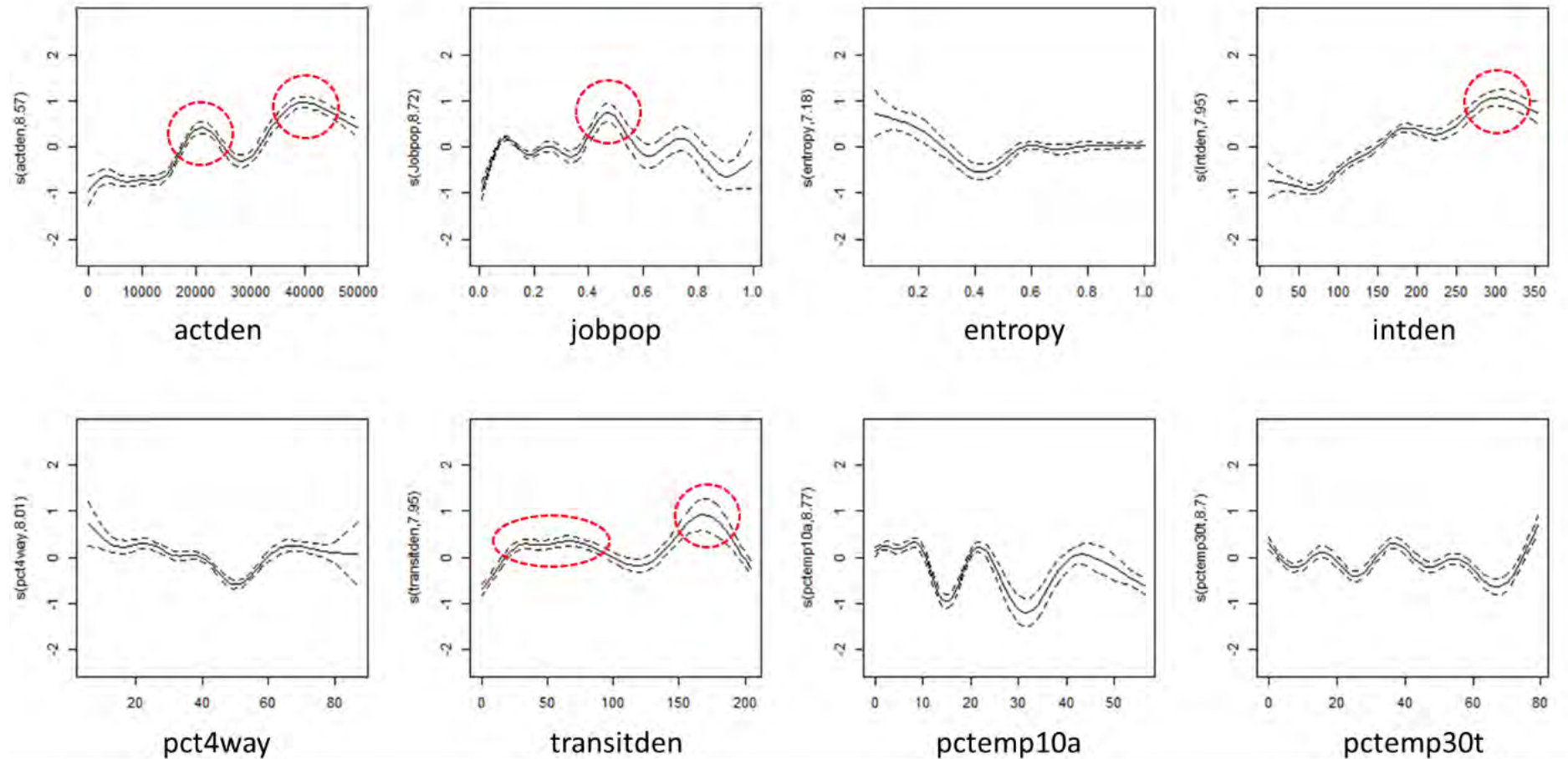


GENERALIZED ADDITIVE MODEL (GAM)

- GAM is a generalized linear model in which the linear predictor depends on local smooth functions of some predictor variables (Hastie & Tibshirani, 1990).
- Ran two GAM models for mode choice and VMT. Mode choice is a categorical variable with three options—walking, transit, and automobile modes—and thus, modeled through multinomial logistic models (reference category: automobile).

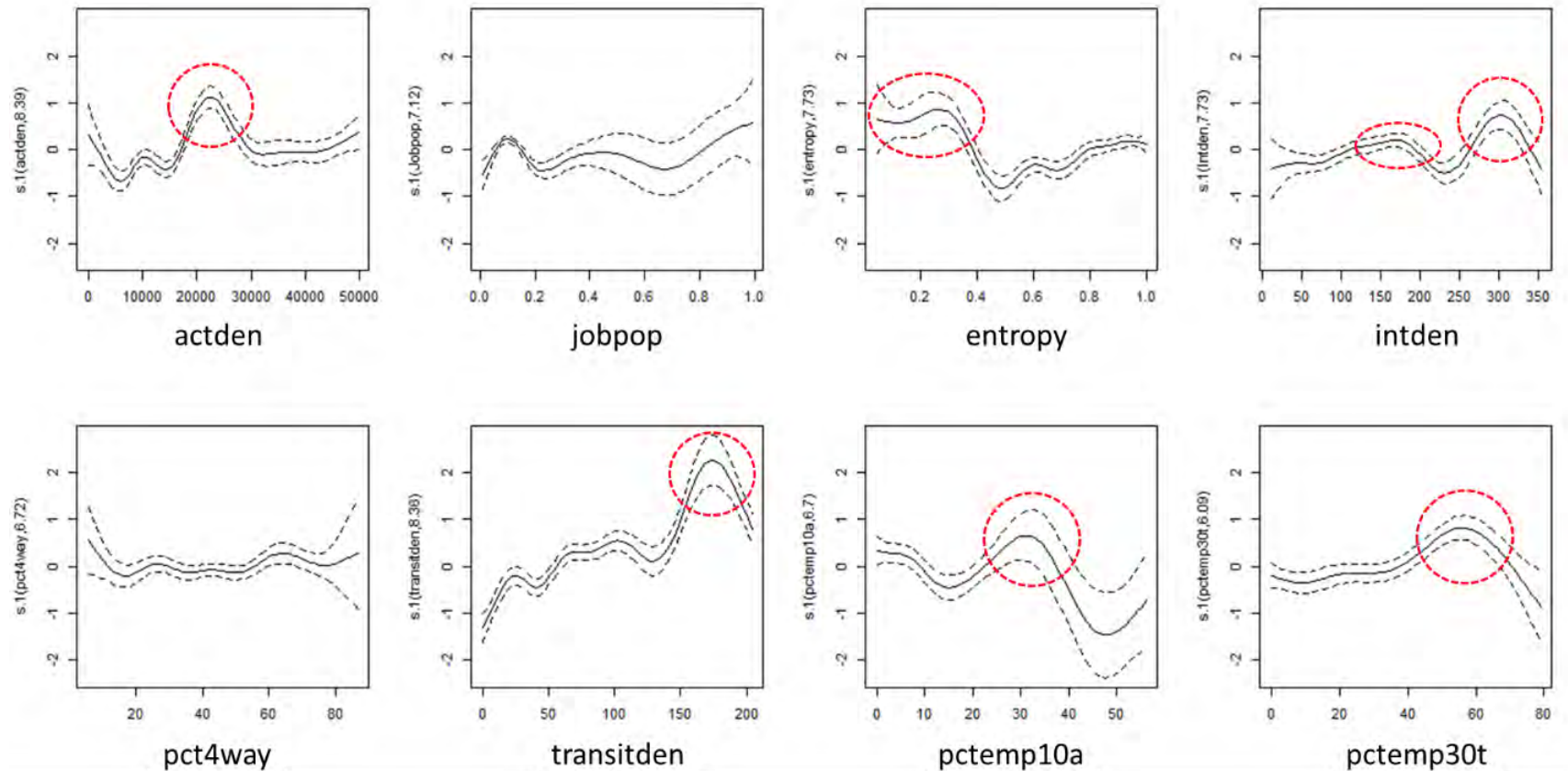
GAM PLOTS BETWEEN 8 VARIABLES AND LIKELIHOOD OF WALK MODE CHOICE

- Red circles indicate potential points to promote walking; Y-axis shows log odds of walk mode choice over driving, centered around zero



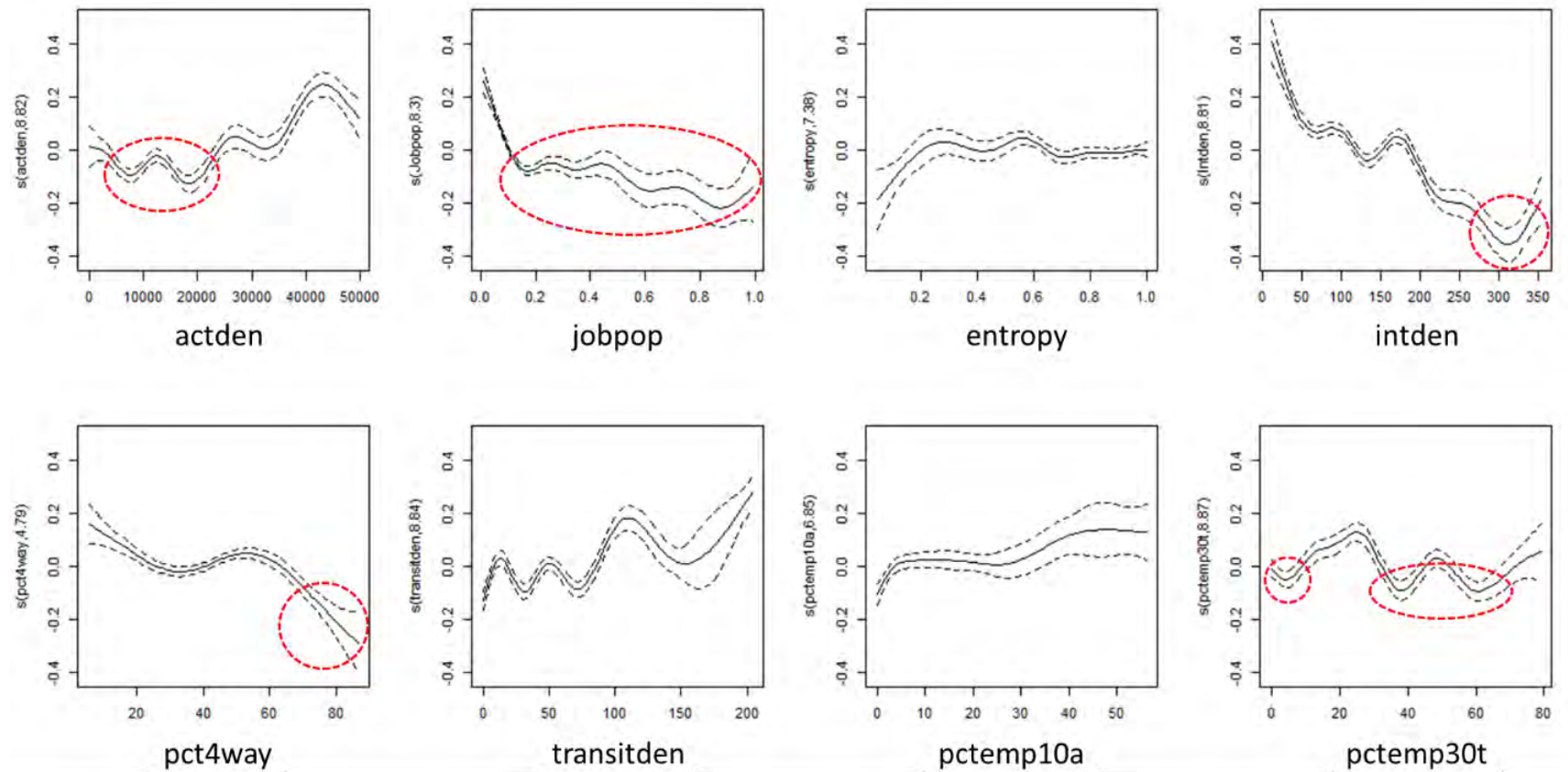
GAM PLOTS BETWEEN 8 VARIABLES AND LIKELIHOOD OF TRANSIT MODE CHOICE

- Red circles indicate potential points to promote transit use; Y-axis shows log odds of transit mode choice over driving, centered around zero



GAM PLOTS BETWEEN D VARIABLES AND VMT

- Red circles indicate potential points to encourage shorter driving; Y-axis shows predicted log-transformed VMT, centered around zero



Built environment variables	Recommendations
Activity density ((pop + emp)/sq.mi.)	10,000-25,000 (according to a center type)
Job-population balance	Minimum 0.2-0.5 (according to a center type)
Intersection density (# intersection/sq.mi.)	Minimum 150-300 (according to a center type)
Percentage of four-way intersections	Minimum 60%
Transit stop density (# stops/sq.mi.)	Minimum 25 (small center) or 150 (large center)
Percentage of regional employment within 30 minutes by transit	Minimum 5% (small center) or 35% (large center)

RECOMMENDATIONS FOR BUILT ENVIRONMENT CHARACTERISTICS OF CENTERS

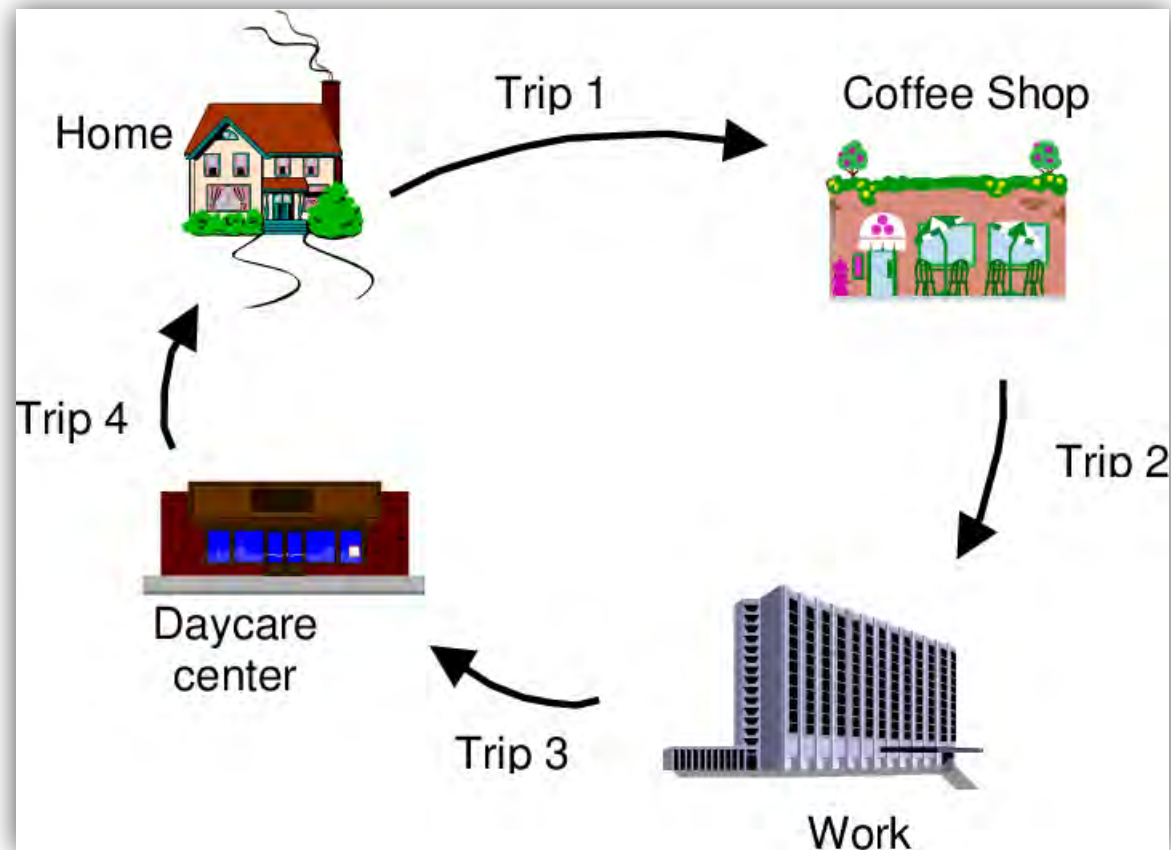


TRIP CHAINING EFFICIENCY IN CENTERS

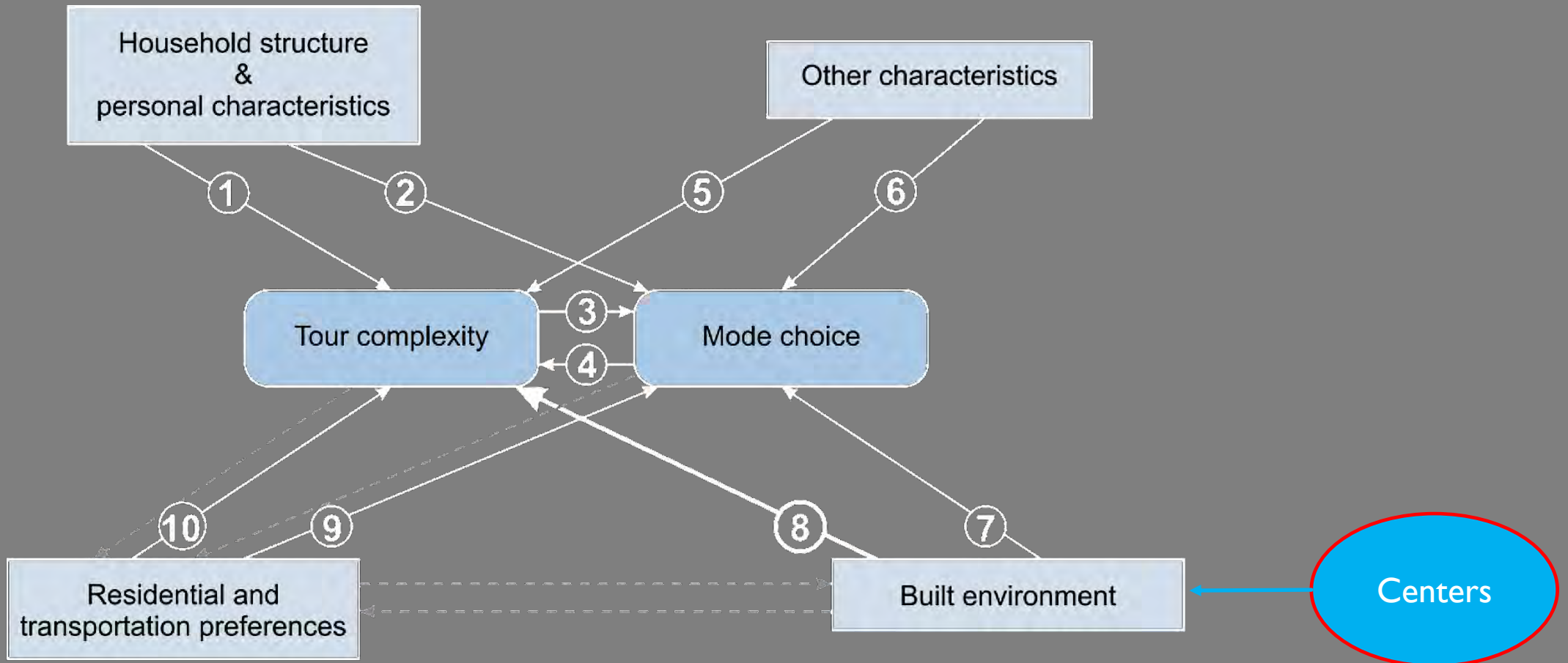


TRIP CHAIN = TRAVEL TOUR

- A travel tour is a sequence of trips that begins and ends at home, also known as a home-to-home loop.



TRIP CHAIN = TRAVEL TOUR



TRIP CHAINING EFFICIENCY

Susilo and Kitamura (2008), Harding et al. (2015), Lee et al. (2017)

- ❖ The higher the proportion of walk, bike, or transit trips, the more efficient the trip chain.
- ❖ The shorter distance of trips by auto, the more efficient the trip chain.

Efficiency =
Sustainable
Transport

Why Trip Chaining?

- ❖ Analyzing trips in isolation cannot capture the true behavior of individuals (Shiftan et al., 2003; Pendyala and Ye, 2005; Frank et al., 2008; Daisy et al., 2018).



New Trend in Transport Models: Tour-Based Models

- ❖ Tour-based modeling “more closely matches the ways in which travel decisions are actually made, and so is more likely to capture true behavioral causality (as opposed to spurious correlations)”
(Frank et al., 2008)



CURRENT GAPS

- ❖ Mixed Results in Terms of the Relationships Between Tour Patterns and the Built Environment
- ❖ None of the Previous Research Focused on Centers

Research Question

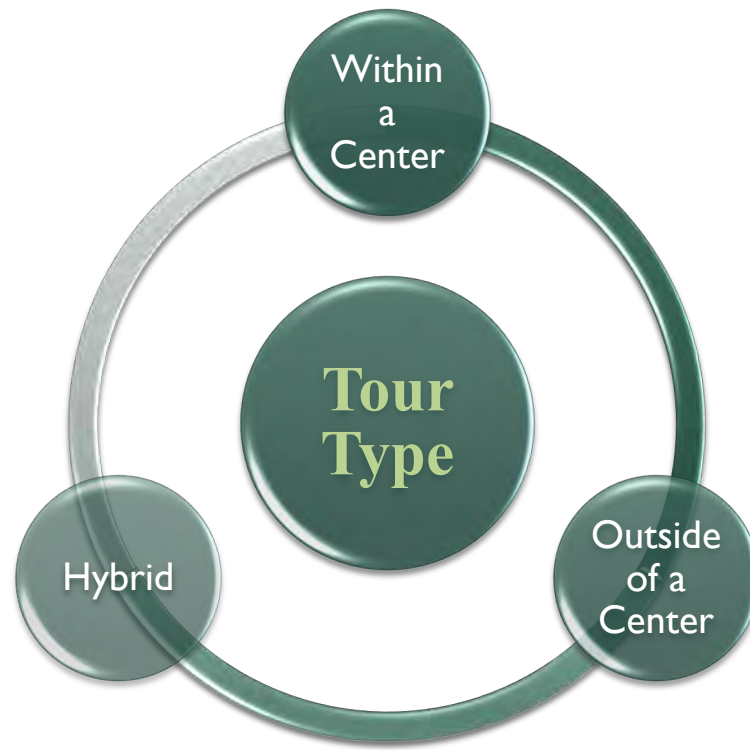
- ❖ Are Tours Associated with Centers More Efficient Than Ones That Are Completely Outside the Centers?
 - ❖ If our expectations are correct, this would be the strongest evidence yet produced on the transportation benefits of polycentric development.

TRIP, MODE SHARE, AND TOUR PATTERNS

- ❖ **Data:** Household Travel Survey for Each Region
- ❖ **Exclusion Criteria:**
 - XY coordinates are not reported.
 - Tours do not start and end at home.

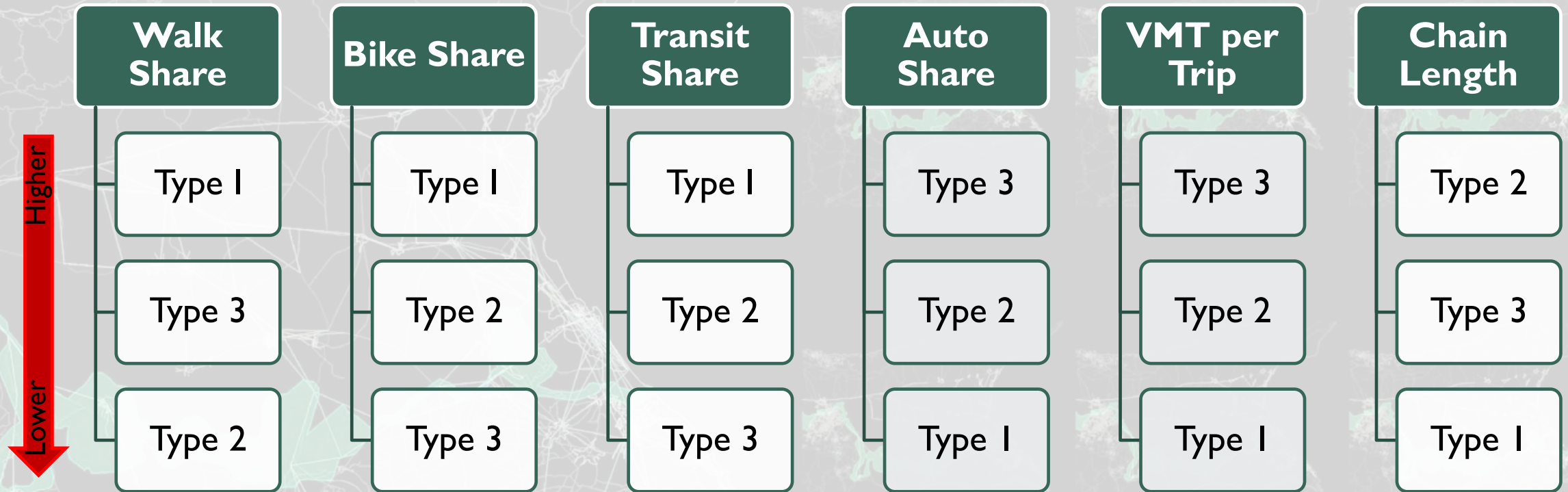
# of Regions	% of Households w/ Vehicle	# of Trips	# of Tours	# of Centers
28	96.1	678,932	235,291	589

TOUR TYPES



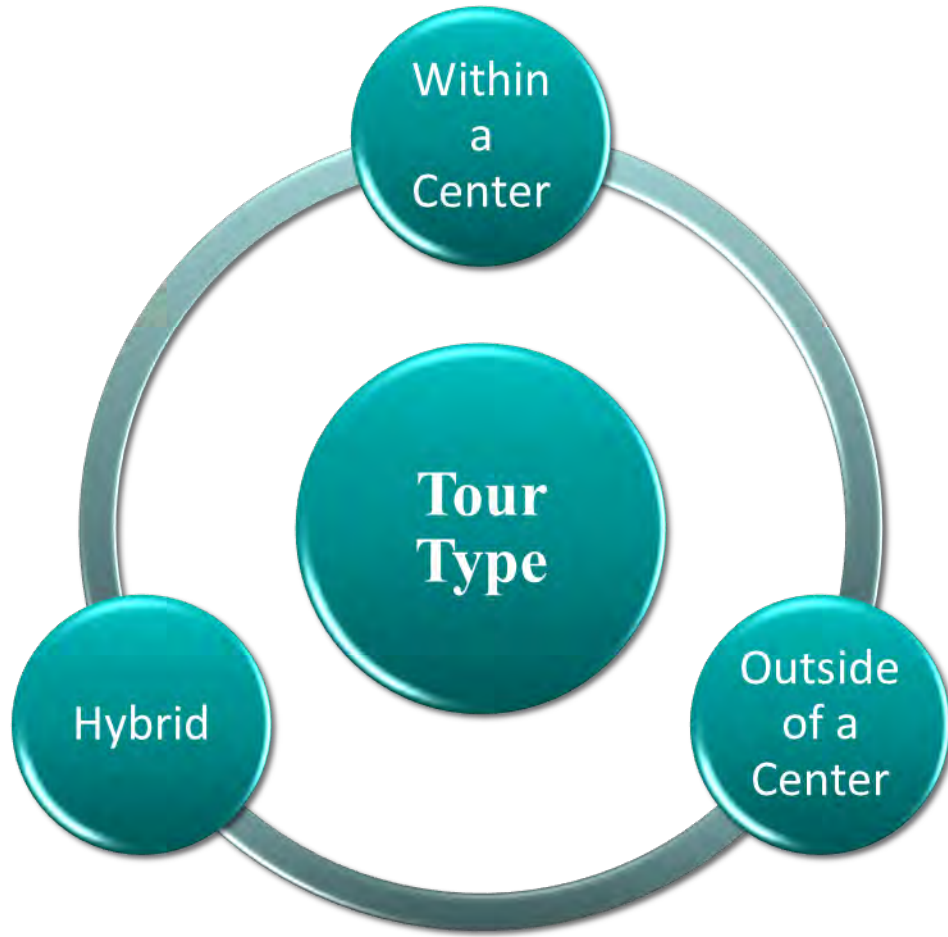
RESULTS – ONE-WAY ANOVA + TAMHANE POST-HOC TESTS

- ❖ All of the comparisons are statistically significant at 0.01 level.

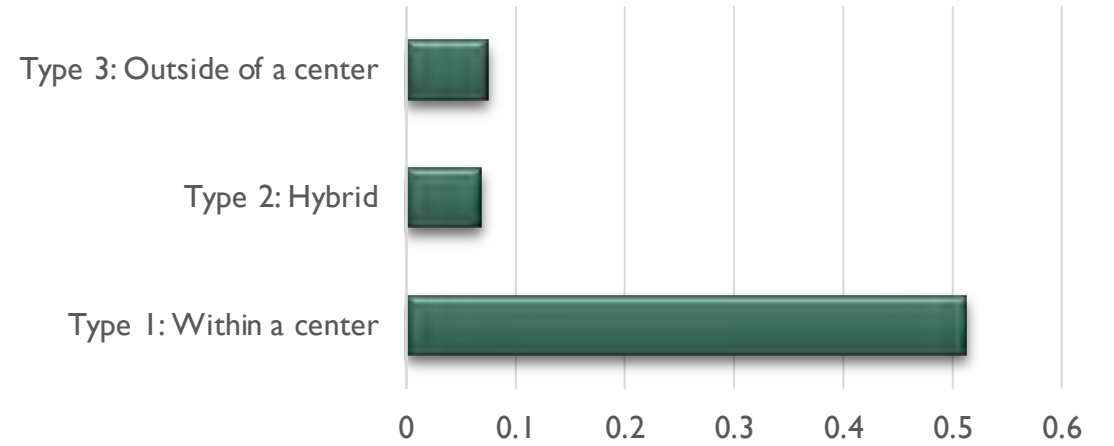


- ❖ Type 1: Tours Within a Center
- ❖ Type 2: Hybrid Tours
- ❖ Type 3: Tours Outside of a Center

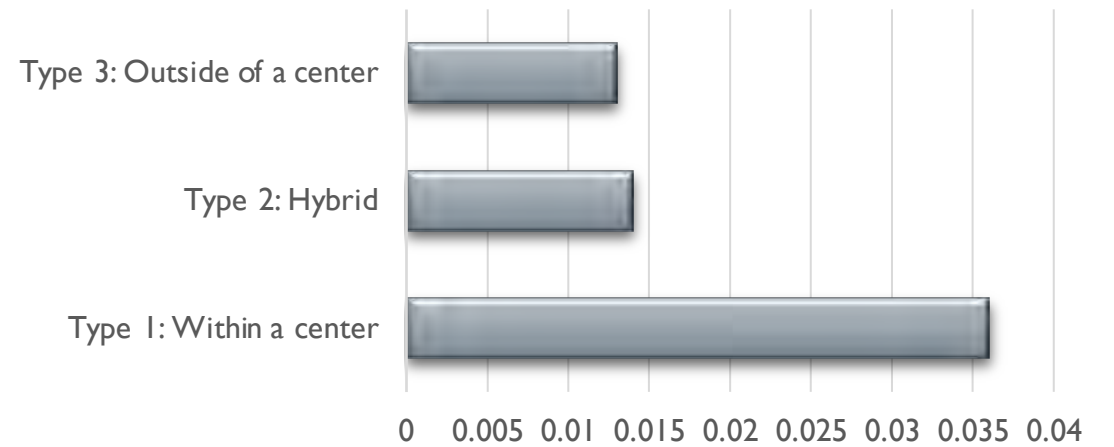
MEAN VALUES



Walk Share

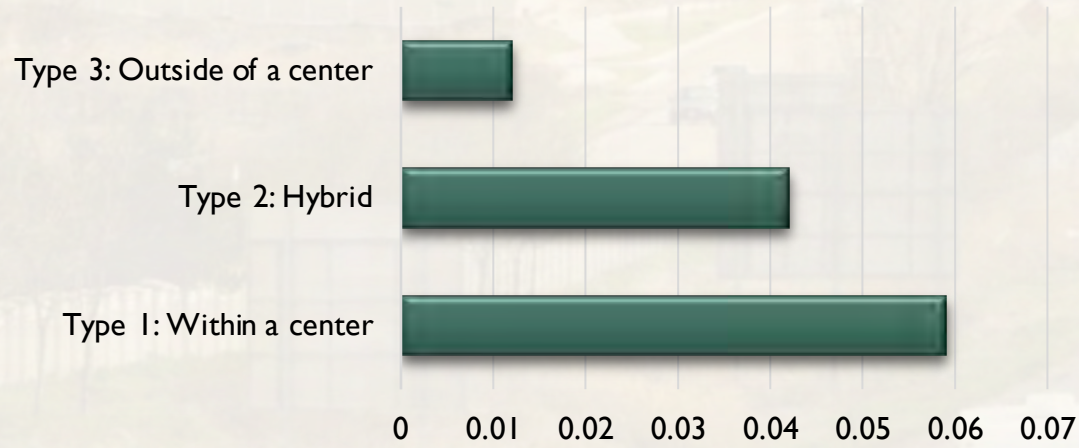


Bike Share

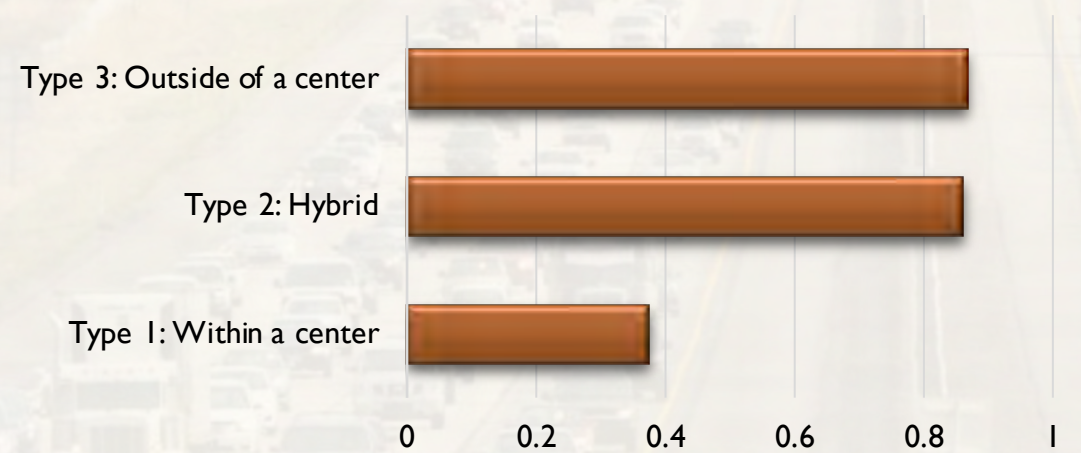


MEAN VALUES (PART II)

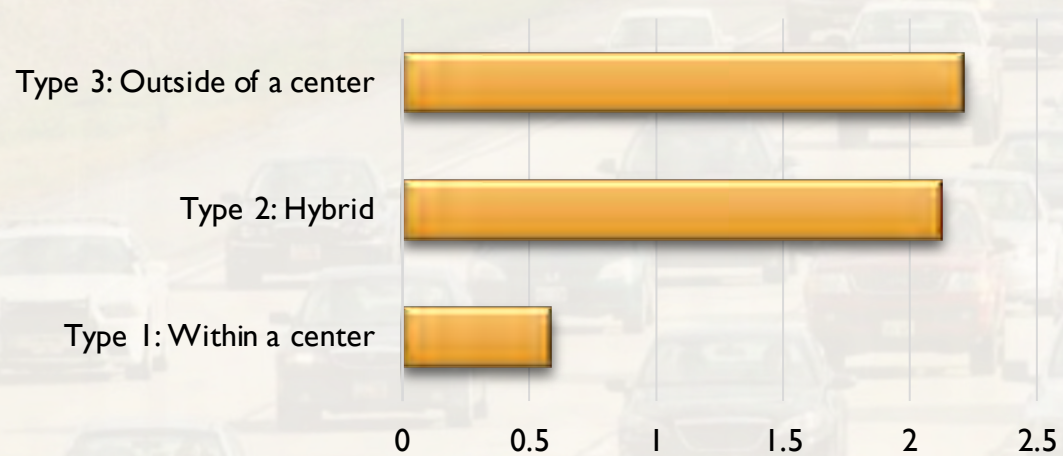
Transit Share



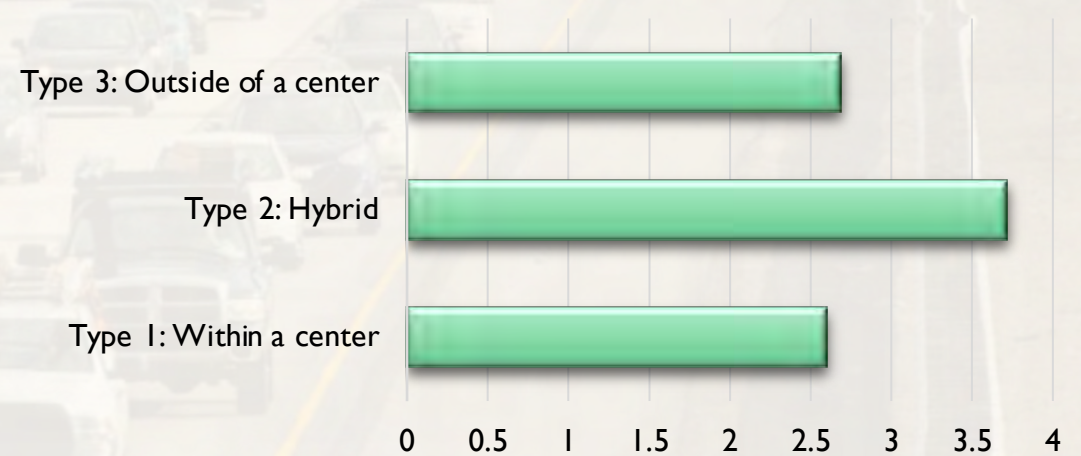
Auto Share



VMT per Trip



Chain Length

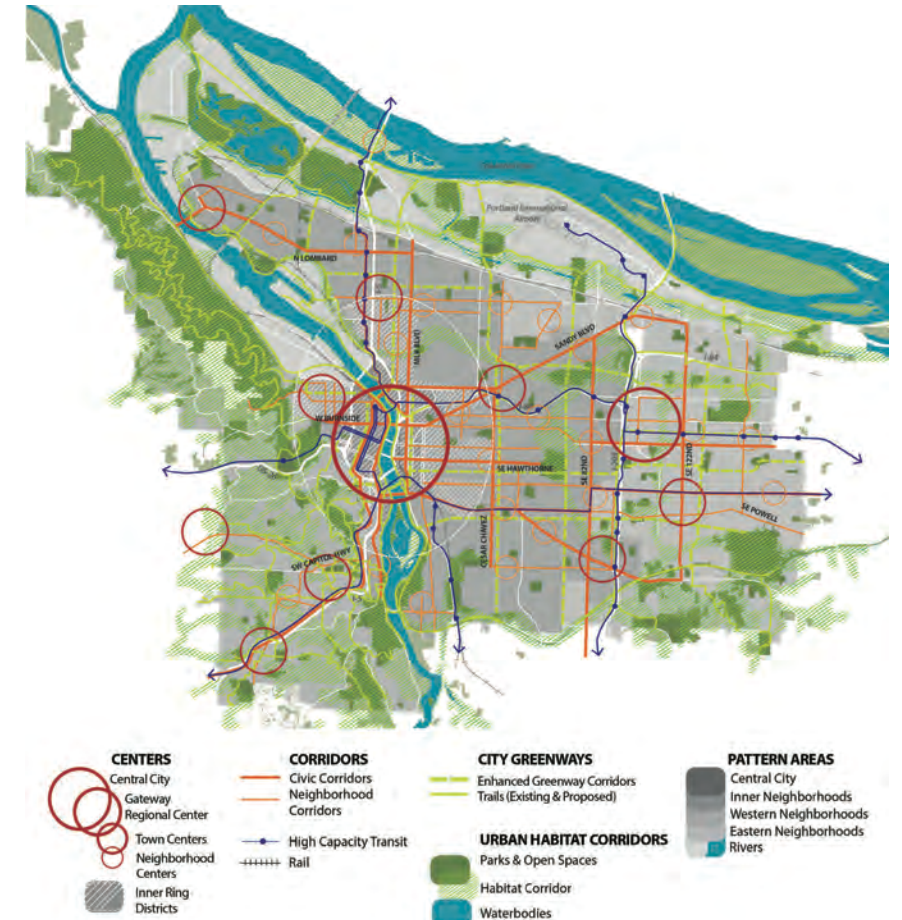
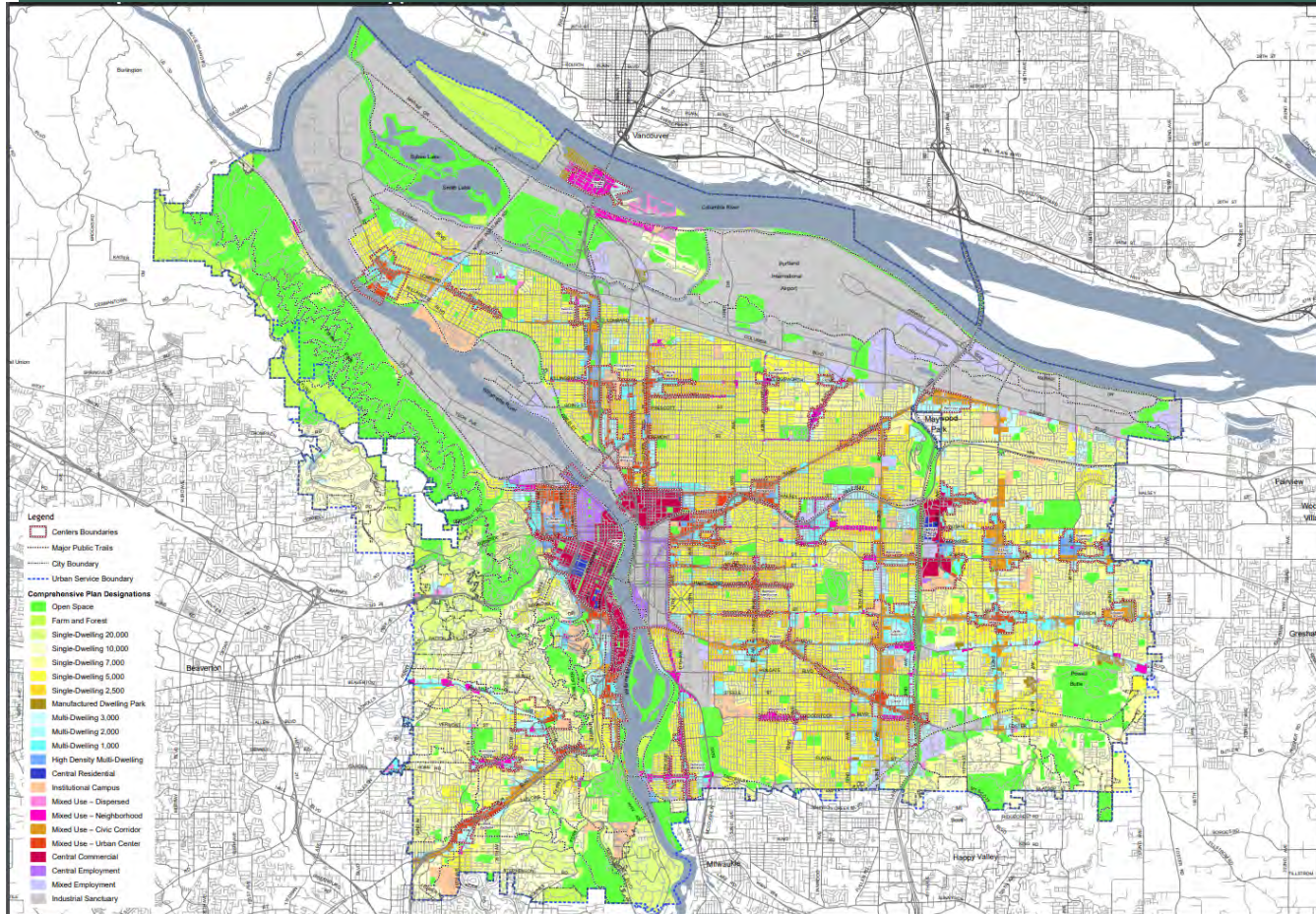




CASE STUDIES



TOOLS AND STRATEGIES OF PORTLAND CITY



2035 Comprehensive Plan has nearly 200 references to centers

TOOLS AND STRATEGIES OF PORTLAND CITY

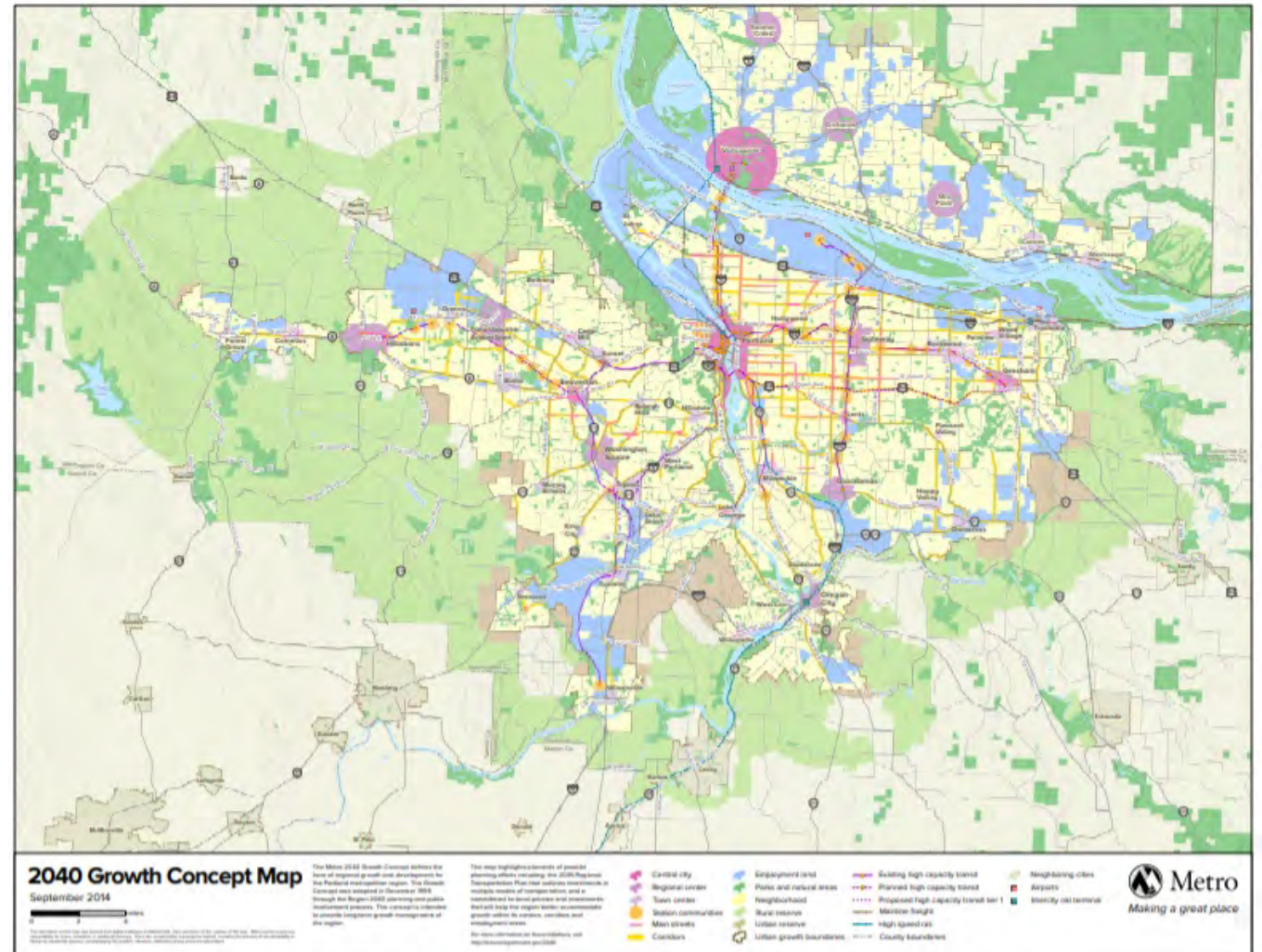
- **Maps** identifying areas for six different levels of multi-family housing density, as well as areas for five different levels of intensity of mixed-use development.
- **Urban Renewal Districts**
- Zoning Map designates a variety of **mixed-use, commercial, and residential zones** that allow adequate density to guide development intensity into centers.
- Comprehensive Plan's parking policies advocate the **redevelopment of surface parking lots** within centers in order to achieve higher densities
- The policy used by the City of Portland that seems to have the most potential to effect polycentric development, however, is the mandate that new developments implement and **operate TDM programs** in order to be permitted and advance to construction.

TOOLS AND STRATEGIES OF PORTLAND CITY- 2035 COMPREHENSIVE PLAN

- **Role of centers.** centers as concentrations of commercial and public services, housing, employment and other services
- **Variety of centers.** Plan for a range of centers to enhance local, equitable access to services, and expand housing opportunities.
- **Housing in centers.** Provide housing capacity for enough population to support a broad range of commercial services, focusing higher-density housing within a half-mile of the center core.
- **Investments in centers.** Encourage public and private investment in infrastructure, economic development, and community services in centers
- **Government services.** Encourage the placement of services in centers,
- **Arts and culture.** land use plans and infrastructure investments allow for and incorporate arts, culture, and performance arts as central components of centers.
- **Accessibility.** Design centers to be compact, safe, attractive, and accessible places, and accessibility by transit, walking, biking, and mobility devices such as wheelchairs, safe and attractive
- **Center connections.** Connect centers to each other and to other key local and regional destinations
- **Green infrastructure in centers.** Integrate nature and green infrastructure into centers

TOOLS AND STRATEGIES OF PORTLAND METRO

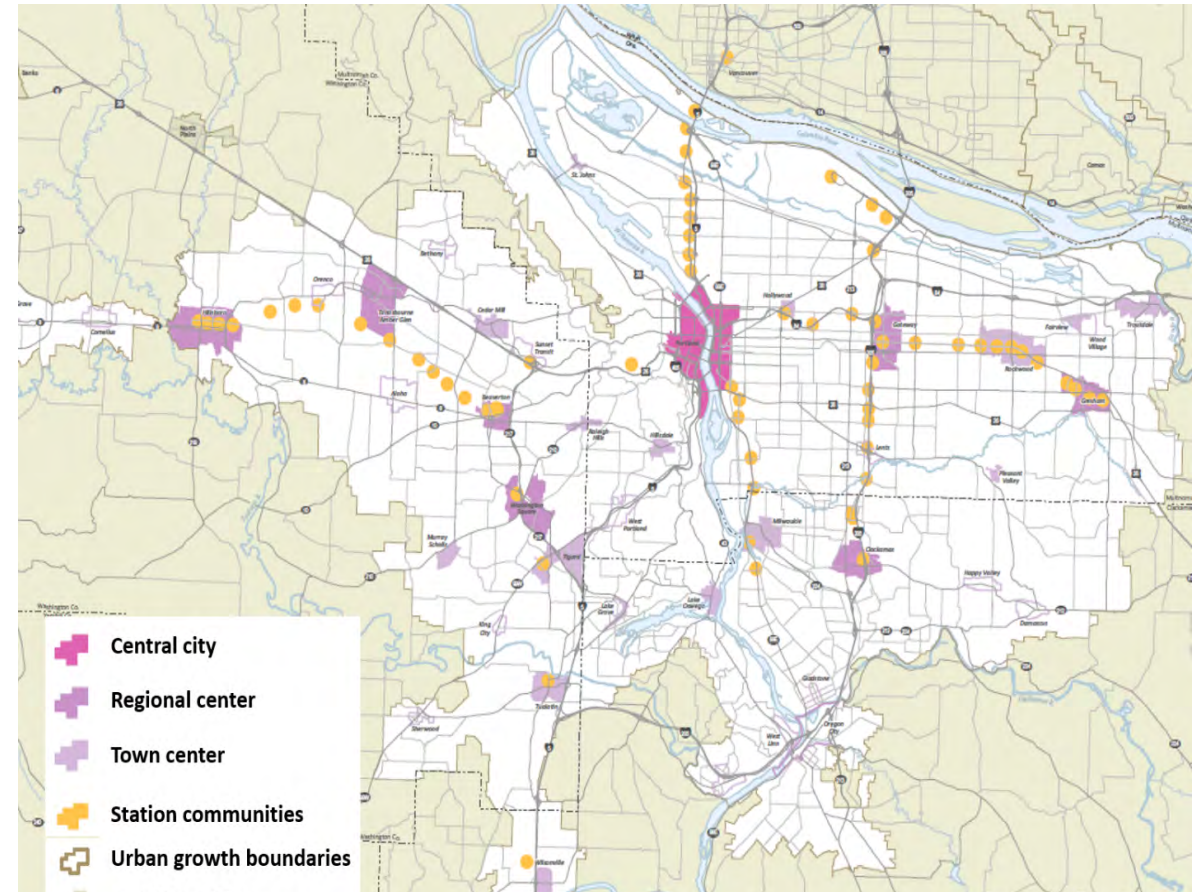
Growth Concept Plan : The concept establishes urban design principles to achieve polycentric development, identifying a central city, regional centers, town centers, neighborhood centers, station communities, and main streets as the typologies for polycentric development.



TOOLS AND STRATEGIES OF PORTLAND METRO

A functional plan, like Portland's Urban Growth Management Functional Plan

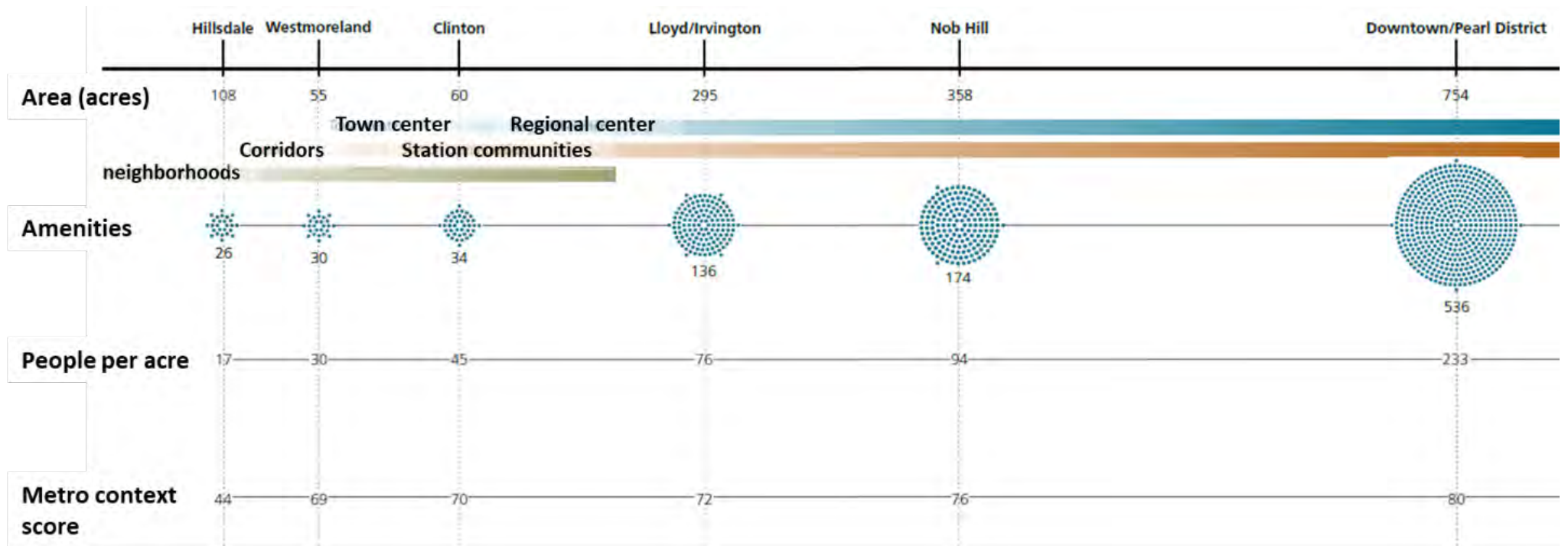
- Calls for minimum housing densities.
- Requirements for consideration of regional funds and investment in centers
- Recommends actual quantified objectives for activity levels within centers.
- The plan defines recommended numbers of residents and workers per square mile for each center type.
- Recommends specific levels and types of mixed-use as well as mixes of housing types.



A functional plan, like Portland's Urban Growth Management Functional Plan

TOOLS AND STRATEGIES OF PORTLAND METRO

- Quantitative indicators by the center hierarchy in the Portland region

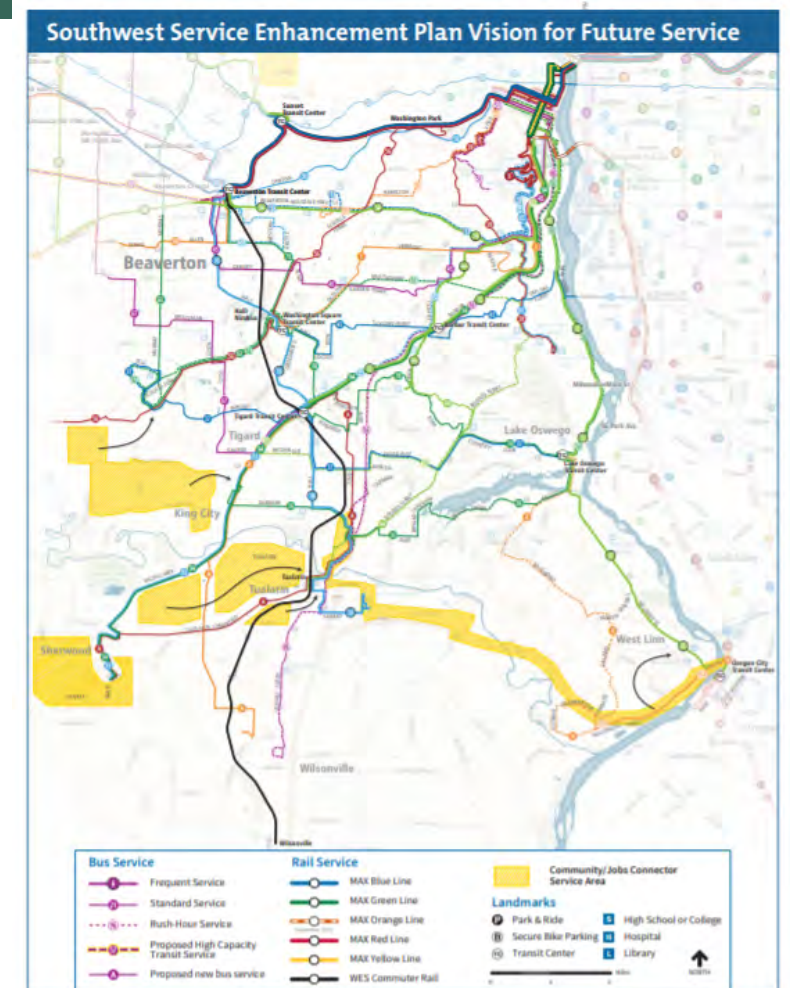


TOOLS AND STRATEGIES OF PORTLAND METRO

- **Metro TOD Program** When transit-oriented or adjacent projects qualify, the TOD program provides funding and support to increase the density of these projects by, ordinarily, increasing the height of buildings. Funding amounts are based on the projected increase that such density would have on transit ridership.
- **The State of the Centers Report** is an effort by Metro to quantify the progress being made in the region to concentrate growth in centers.
- **2040 Planning and Development Grants.** This program provides grants to local governments to plan for development that is aligned with the 2040 Growth Concept
- **Title VI Centers Functional Plan** first implemented in 2002 by Portland Metro with the intention of helping cities within the region promote and grow their centers.

TOOLS AND STRATEGIES FOR TRIMET TRANSIT AGENCY

- Connecting centers through corridors with high-quality alternatives to auto travel, like transit
- Prioritizing Active Transportation for connecting centers



MORE CASE STUDIES

- Minneapolis-St. Paul
- Seattle
- Denver

THANK YOU

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