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# BUILT ENVIRONMENT CRITERIA FOR POLYCENTRIC DEVELOPMENTS

:TO REDUCE VEHICLE USE AND INCREASE WALKING AND TRANSIT USE

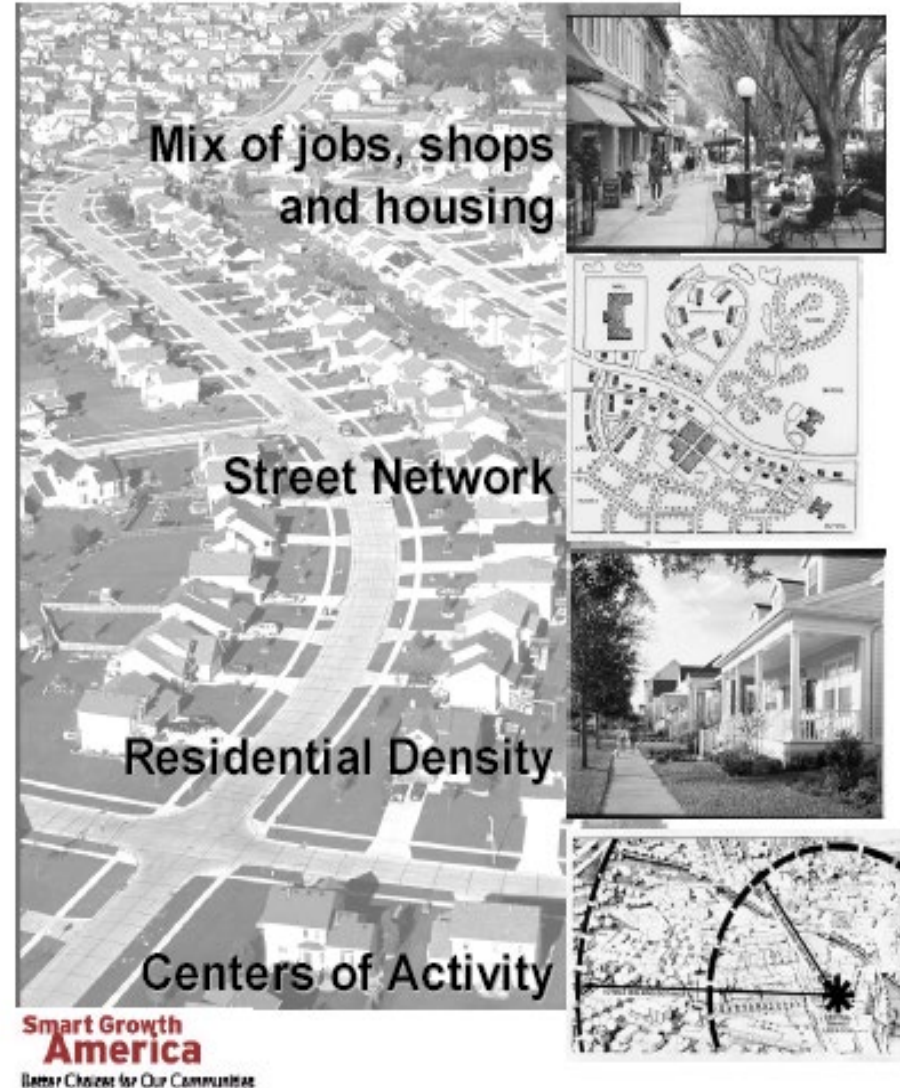
KEUNHYUN PARK, REID EWING,  
SADEGH SABOURI, DONG-AH CHOI,  
SHIMA HAMIDI, & GUANG TIAN



# MEASURING SPRAWL AND ITS IMPACTS

## MEASURING SPRAWL AND ITS IMPACT

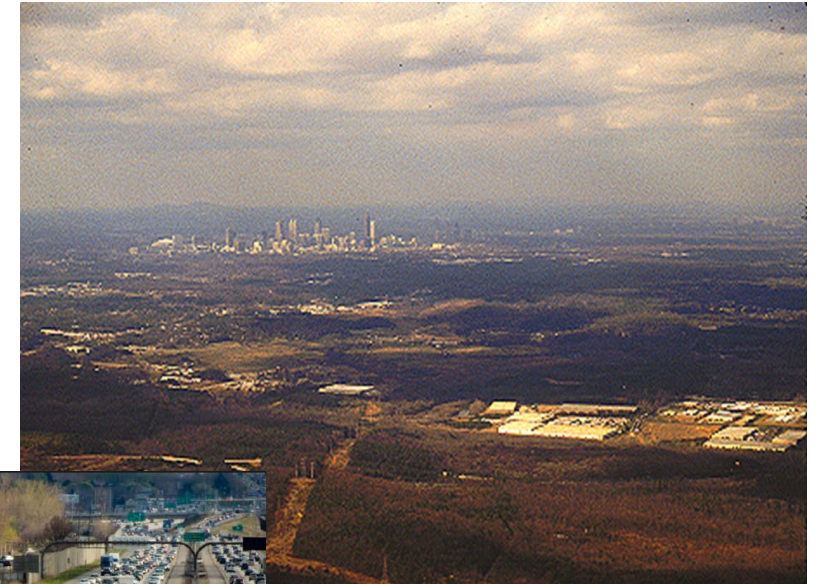
Reid Ewing, Rutgers University, Rolf Pendall, Cornell University, Don Chen, Smart Growth America



Released October 2002

# 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)

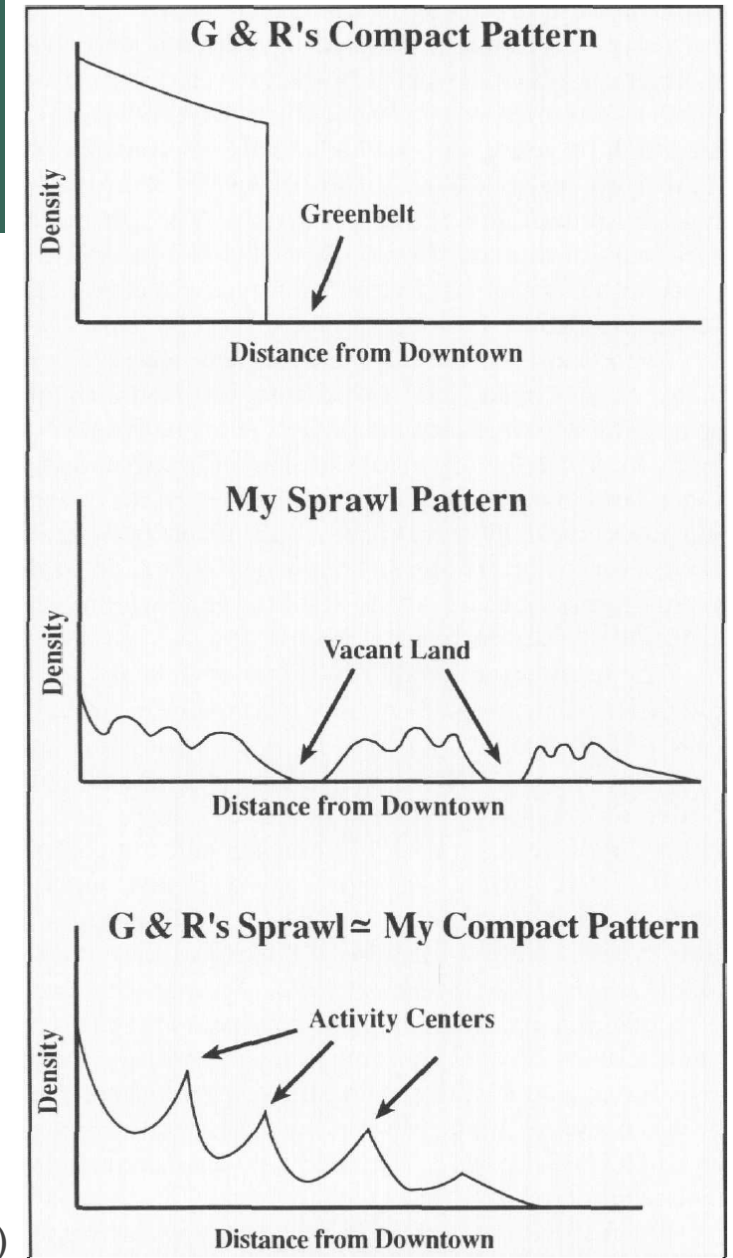
**Teenage driving** (Trowbridge and McDonald, 2008; McDonald and Trowbridge, 2009)

**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

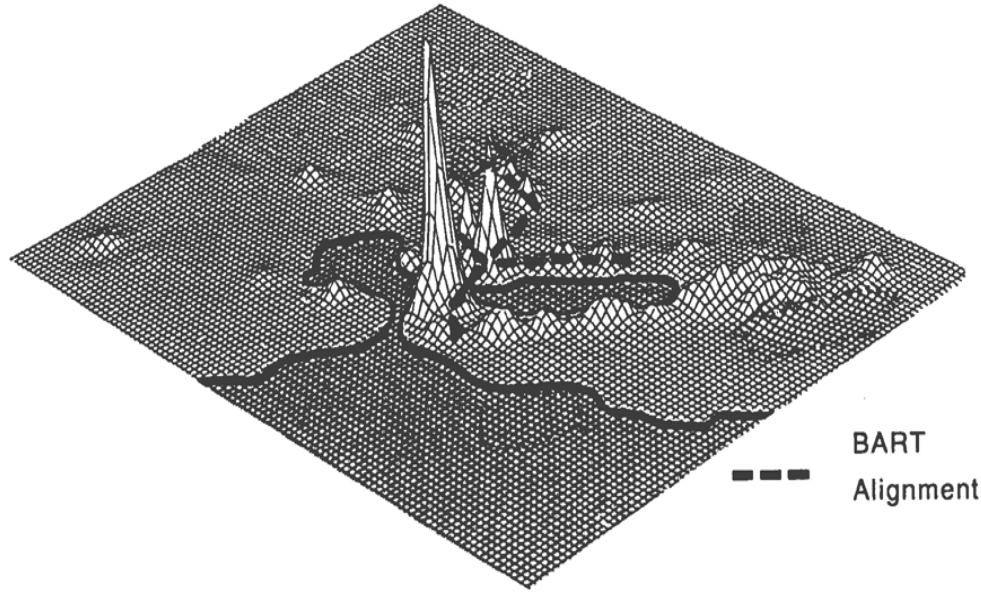
- **Center:** the densest parts of a region, characterized by compact and mixed-use development, well-connected by a multi-modal transportation network, and with more job opportunities than the areas around them
- **Polycentric development:** a regional development pattern consisting of multiple centers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



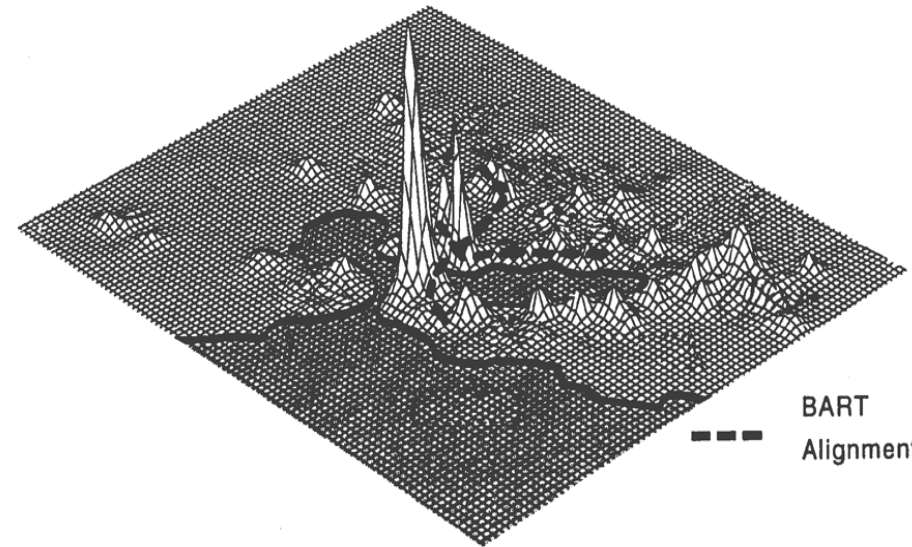
(Ewing, 1997)

# SUBCENTERING OF DEVELOPMENT

**1980**



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BART  
Alignment



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BART  
Alignment

**1990**

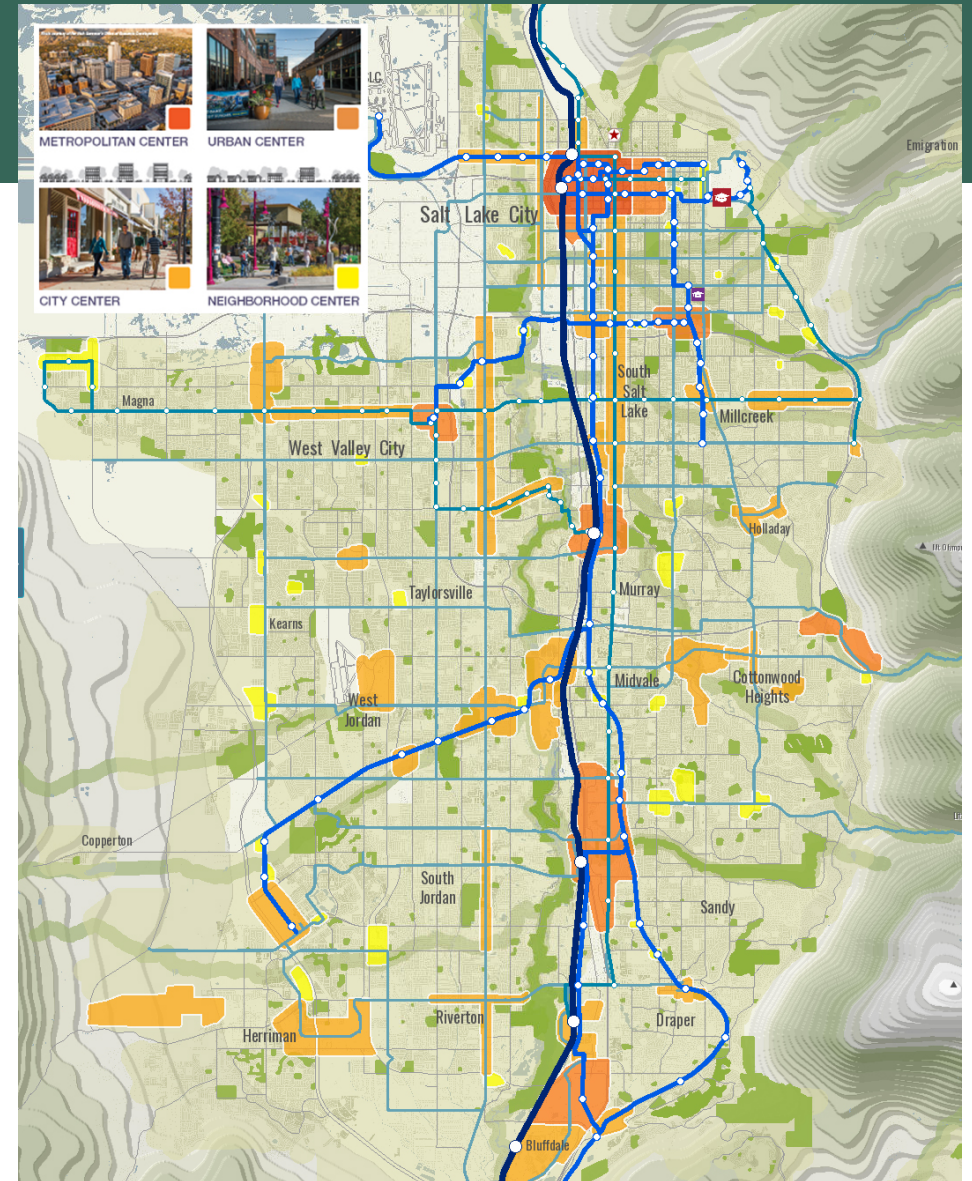


# COMPACT DEVELOPMENT A LA U.S.





# REGIONAL & NATIONAL FUNDING



## WHAT DOES LITERATURE SAY?

- The correlation between population size and transportation costs was also theoretically demonstrated to cause subcenter creation (Fujita & Ogawa, 1982; McMillen & Smith, 2003)
- Gross employment density and the employment-population ratio were other measures used to identify subcenters (McDonald, 1987; Anderson & Bogart, 2003)
- Objective measures defining polycentricism are lacking in policy documents and plans (Masip-Tresserra, 2016), and evidence that polycentricism provides transportation benefits is in even shorter supply (Ewing & Hamidi, 2017)

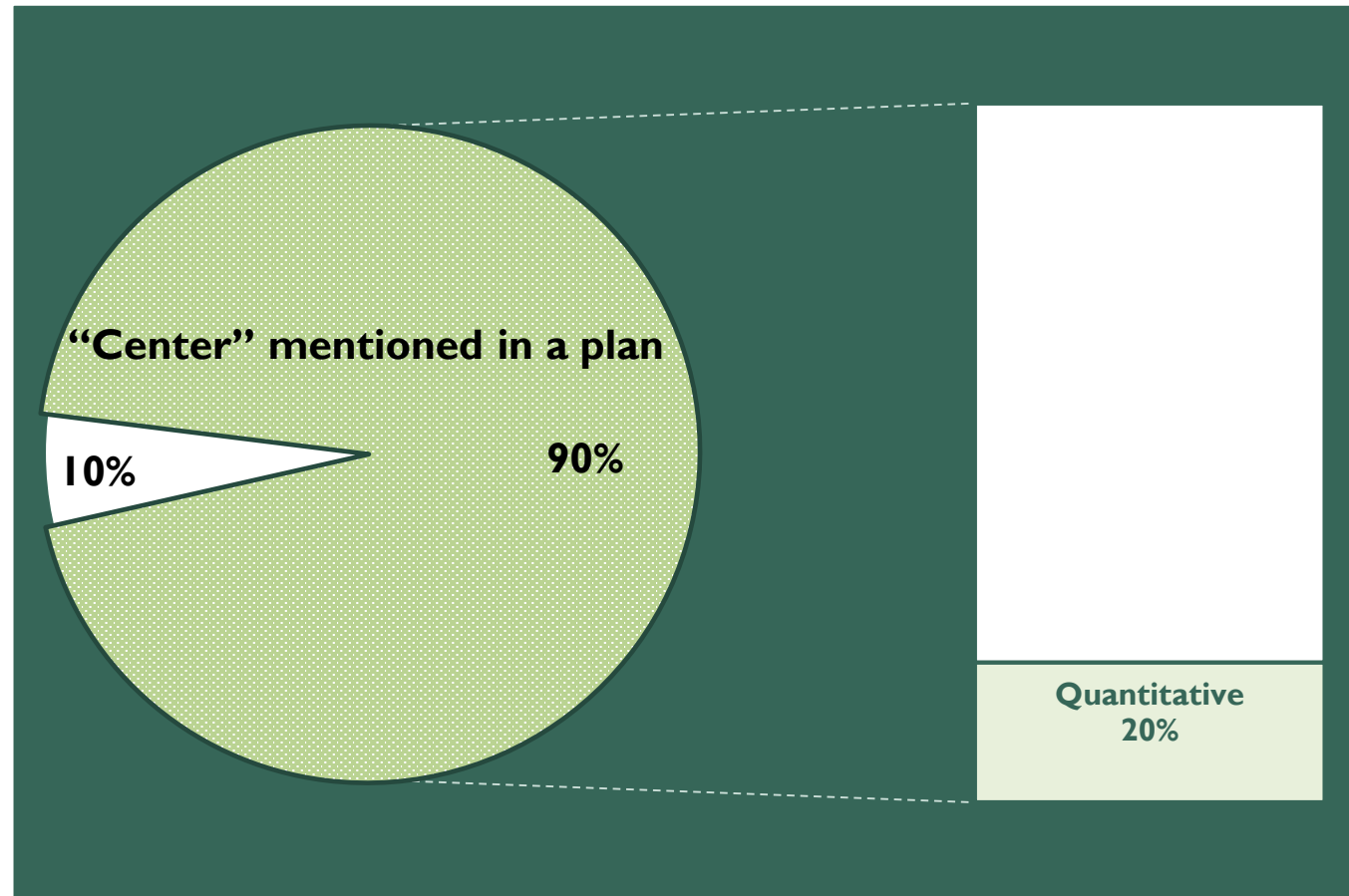
## POLYCENTRIC DEVELOPMENT IN REGIONAL TRANSPORTATION PLANS

- We reviewed 126 regional transportation plans (RTPs) across the U.S. to check how centers are defined and proposed both qualitatively and quantitatively

Center Type	Counts	Center Type	Counts
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

- “the densest part of an area, characterized by compact and mixed-use development, multiple transit options, and employment opportunities”
- 90% (112 out of 126) mentioned “center,” but **only 20% of them (n=25) get quantitative**
- Suffering from a lack of consistent indicators to designate centers and guide their developments
- **Quantitative measures:** employment density, residential density, area size, land use mix, building design, transit service, and street density





# Denver, CO

Figure 9  
Urban Centers

- *Mixed-use centers* are envisioned as high-intensity, pedestrian-oriented, mixed-use locations, providing a range of retail, business, civic and residential opportunities for the surrounding trade area.



- *Activity centers* are similar, but focused mostly on employment. They may not contain the same mix of uses, particularly residential.



- *Regional corridors* have some residential components, but are distinguished by their larger size, linear characteristics and adjacency to major transportation corridors. Regional corridors can be thought of as a series of interconnected urban centers.



# 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

# 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



# 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. Identify potential employment subcenters

Clusters of high employment density that are far from CBDs based on Geographically Weighted Regression (GWR)



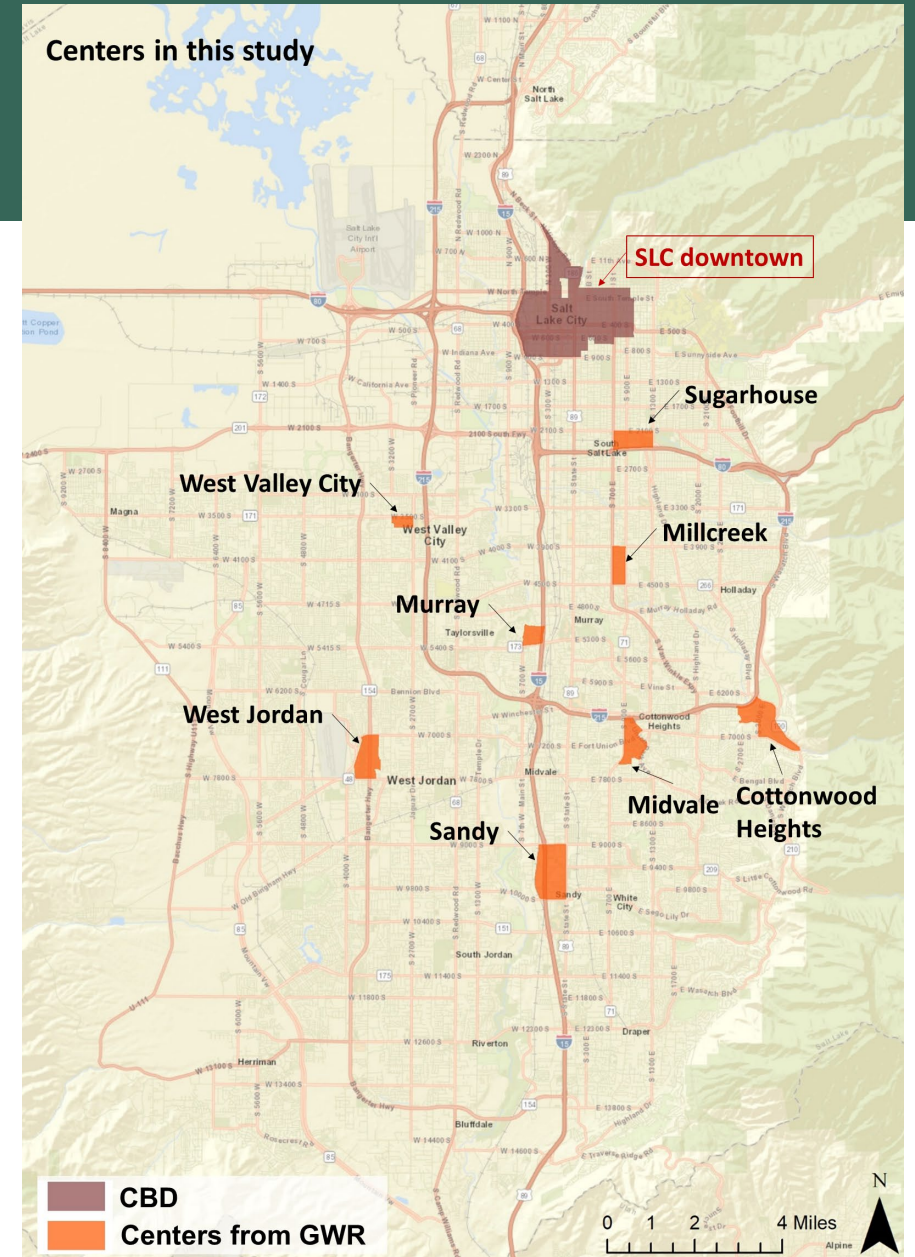
### 3. Apply exclusion criteria

1) more than one employment sector, 2) mix of Job/population



### 4. Validate result by a regional plan

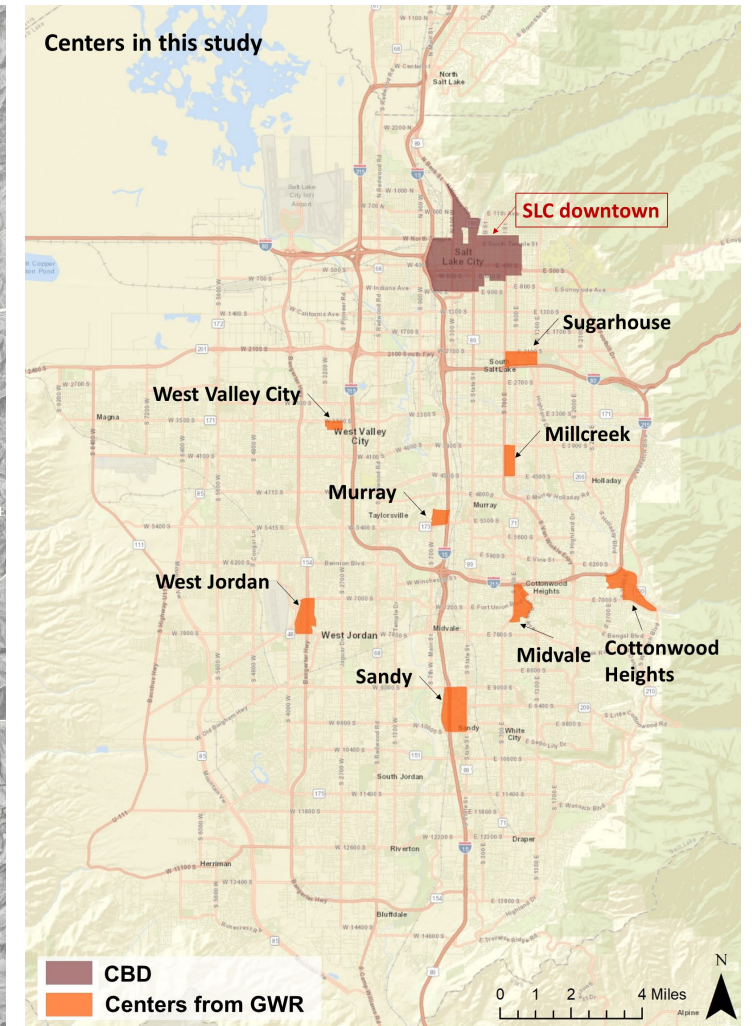
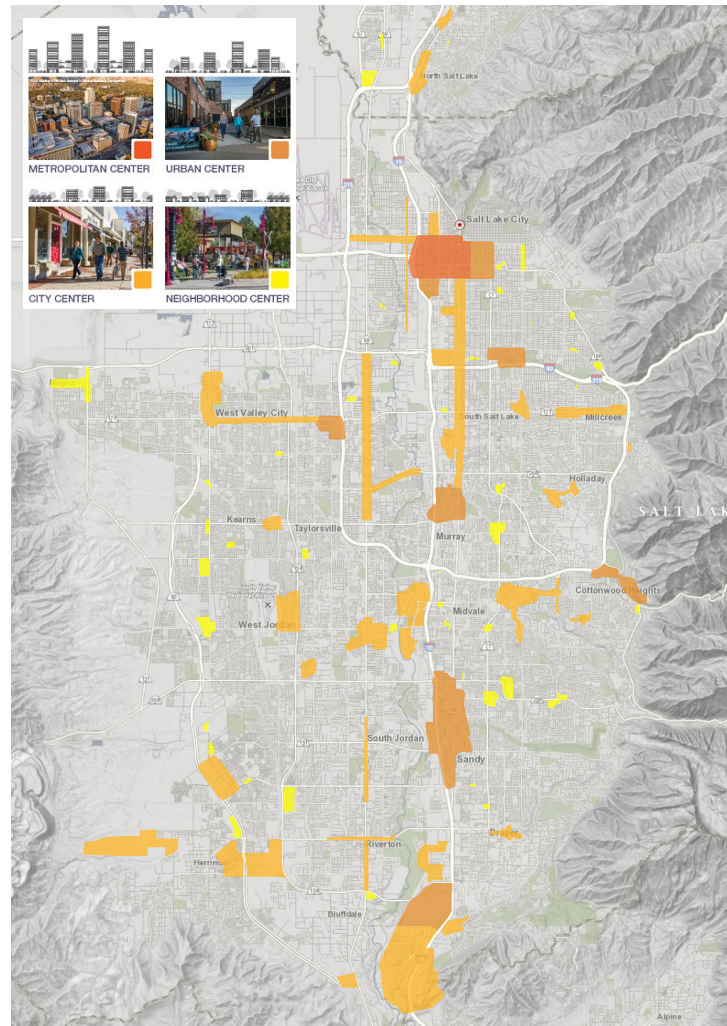
589 centers identified in 28 U.S regions





# IDENTIFIED CENTERS VS. WASATCH CHOICE 2050

## Salt Lake County, UT



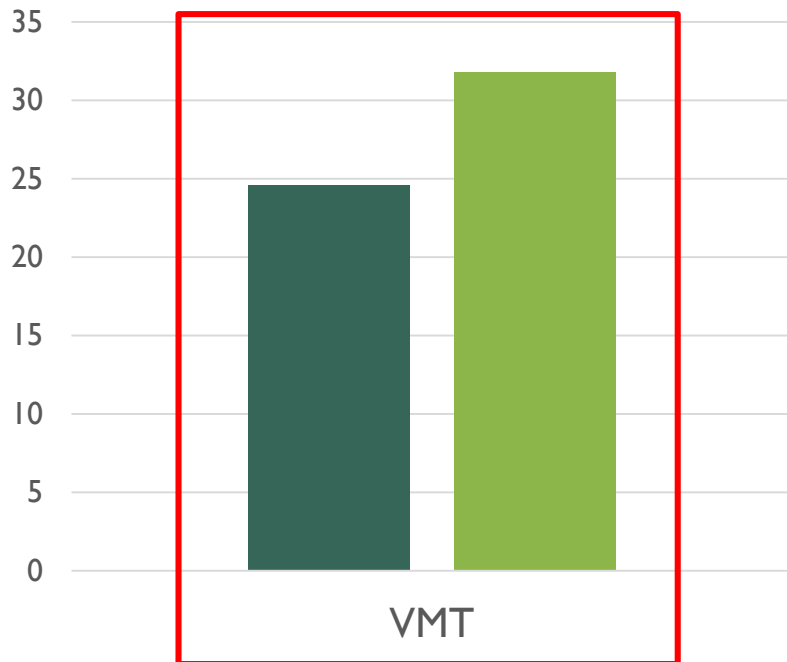
# TRAVEL OUTCOMES WITHIN / OUTSIDE CENTERS

**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

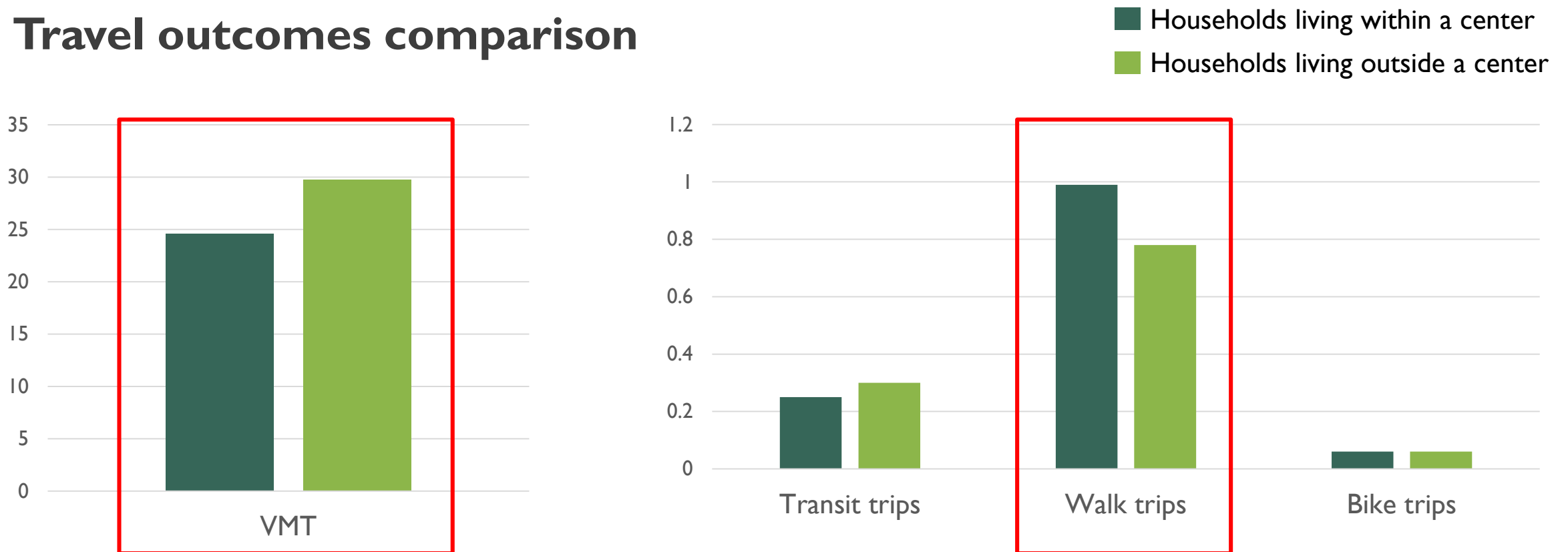


# TRAVEL OUTCOMES WITHIN / OUTSIDE CENTERS BASED ON PROPENSITY SCORE MATCHING

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

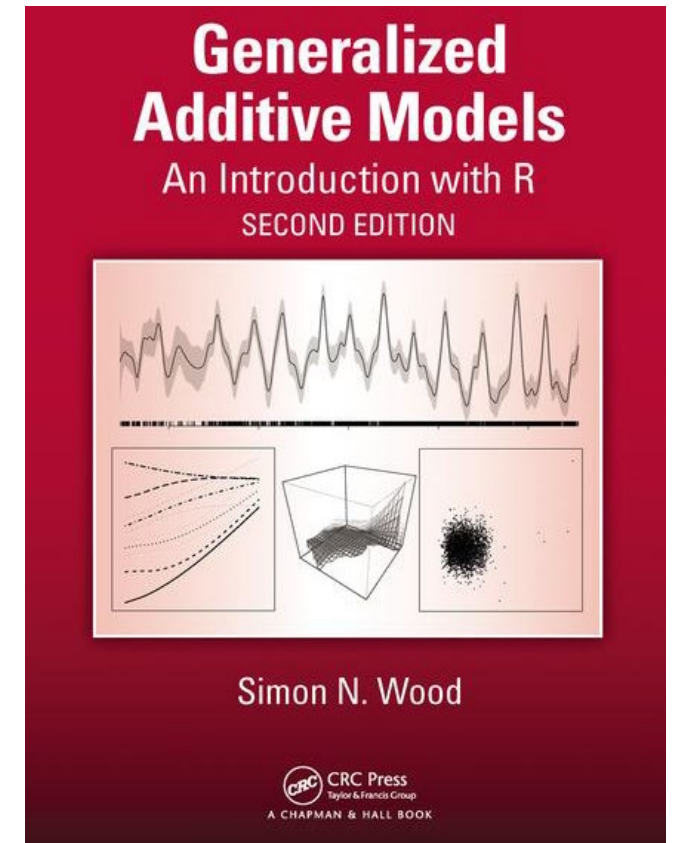
- 589 centers; 1,498 households within centers vs. 1,498 households outside centers

## Travel outcomes comparison



# GENERALIZED ADDITIVE MODEL (GAM)

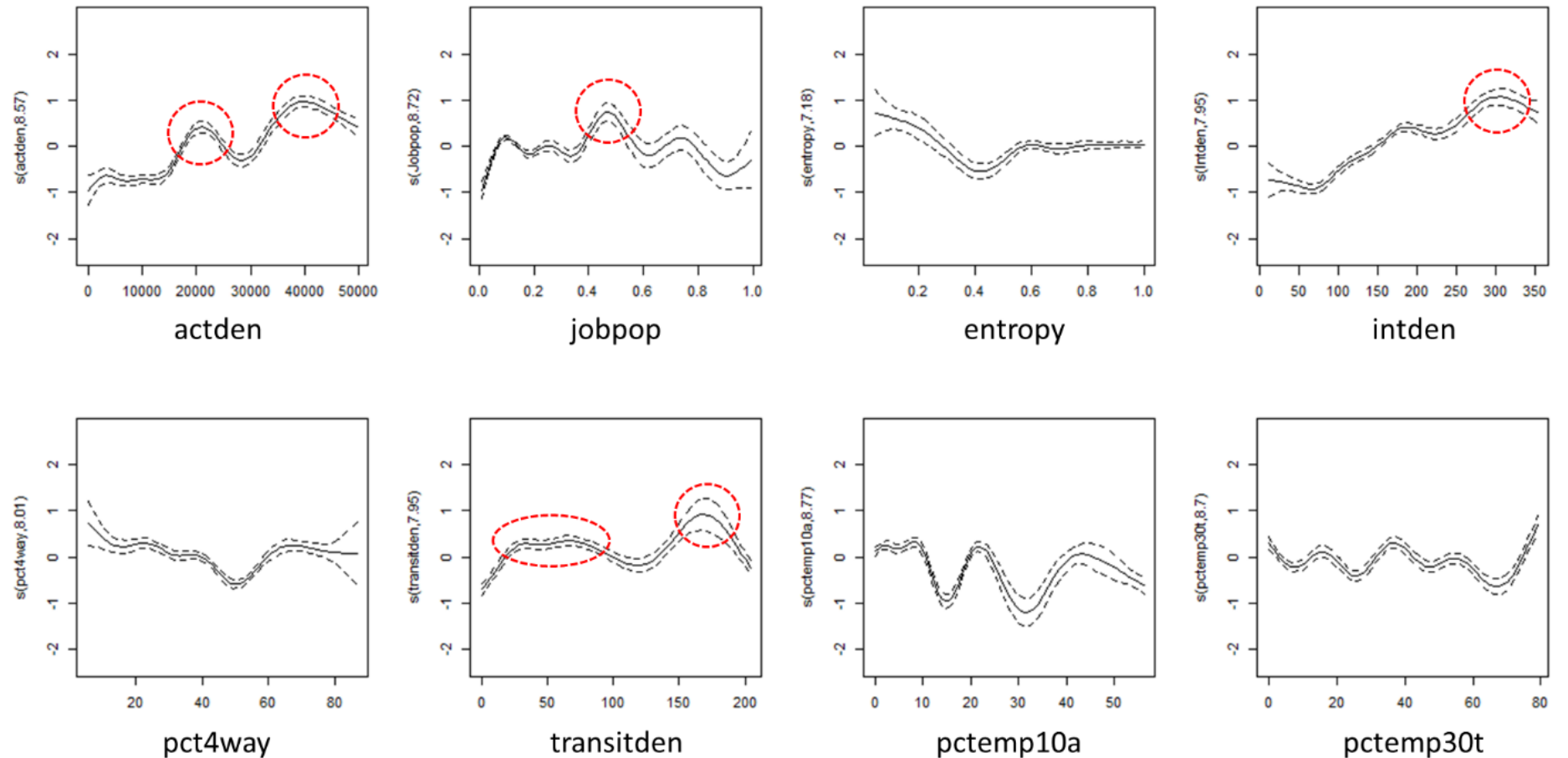
- Generalized additive model (GAM) is a generalized linear model in which the linear predictor depends on local smooth functions of some predictor variables (Hastie & Tibshirani, 1990)
- Ran **two GAM models for mode choice** (multinomial) and **VMT** (linear)





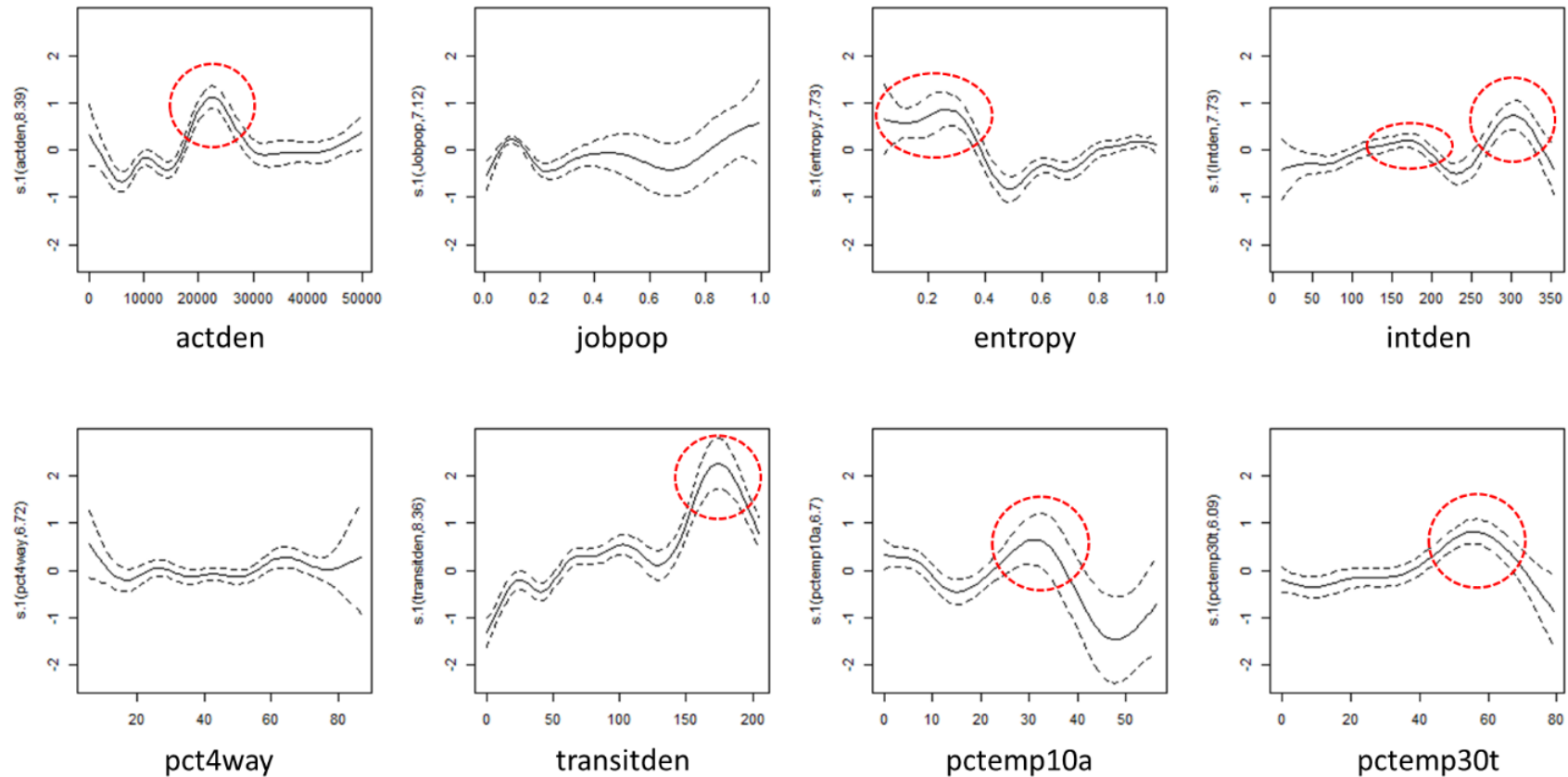
# GAM PLOTS BETWEEN 8 VARIABLES AND LIKELIHOOD OF WALK MODE CHOICE

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



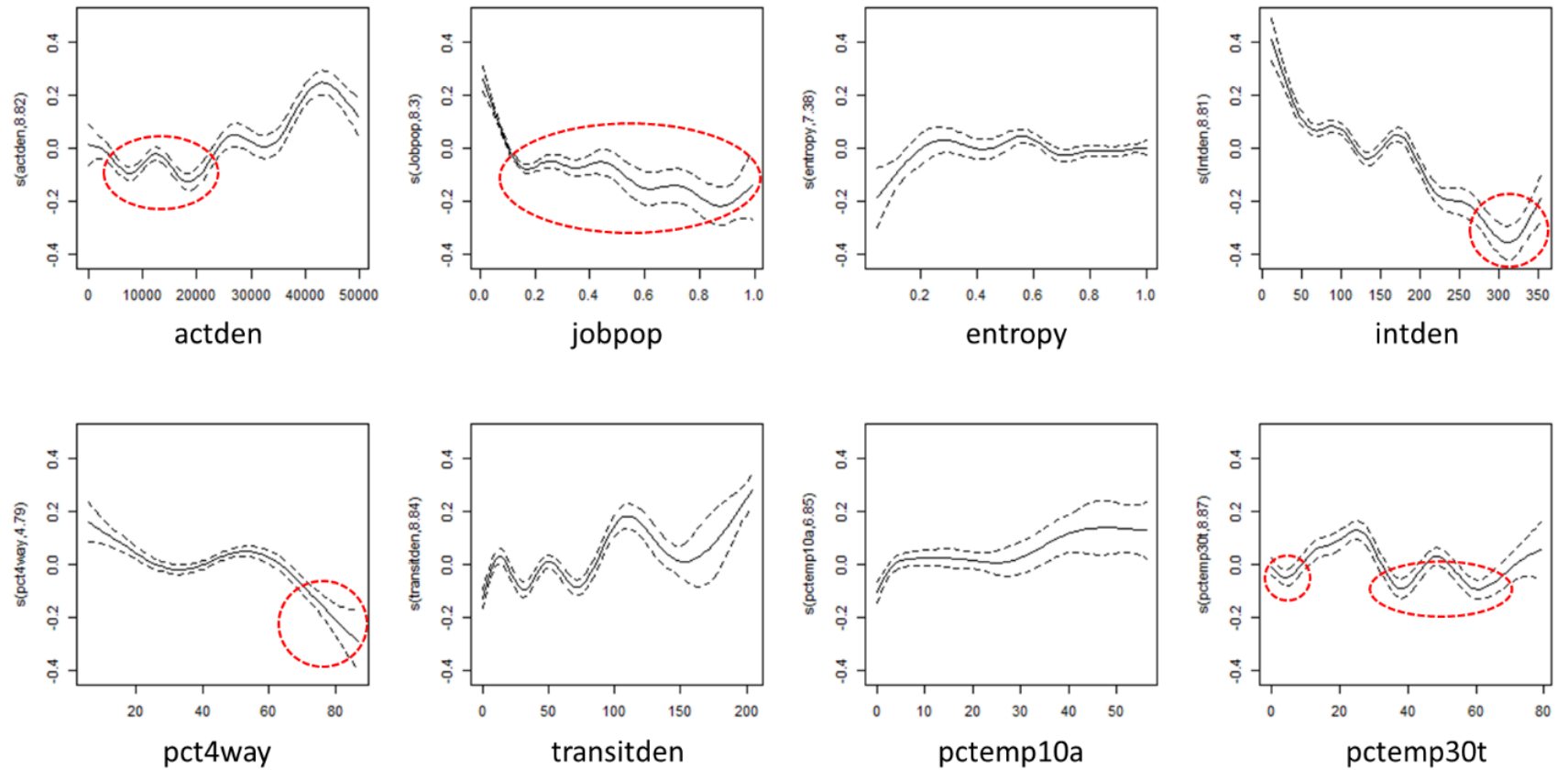
# GAM PLOTS BETWEEN 8 VARIABLES AND LIKELIHOOD OF TRANSIT MODE CHOICE

- 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



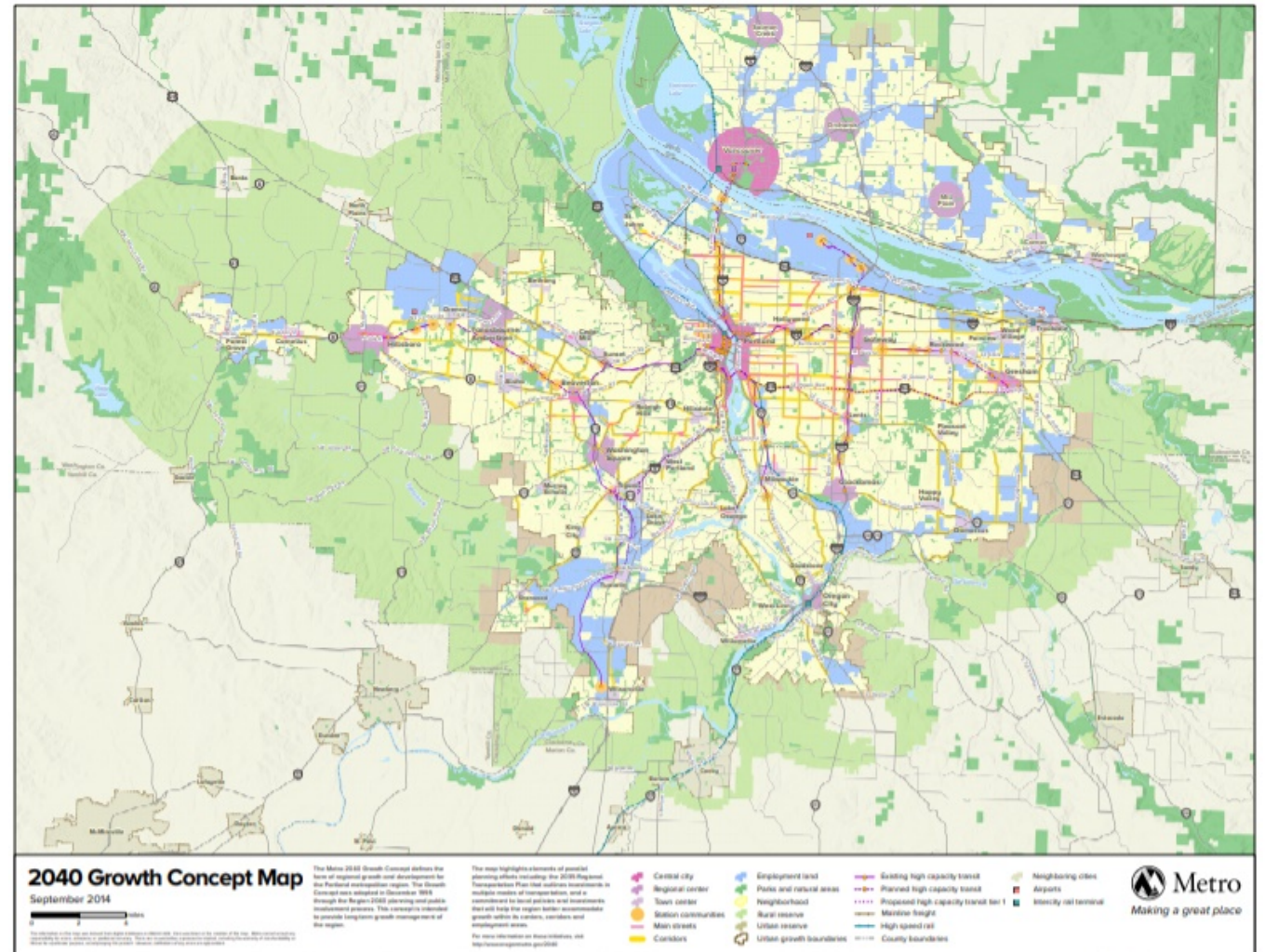
# CASE STUDIES IN POLYCENTRIC DEVELOPMENT POLICY

- Portland
- Minneapolis/St Paul (in progress)
- Seattle (in progress)
- San Diego (planned)
- Denver (planned)



# 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.

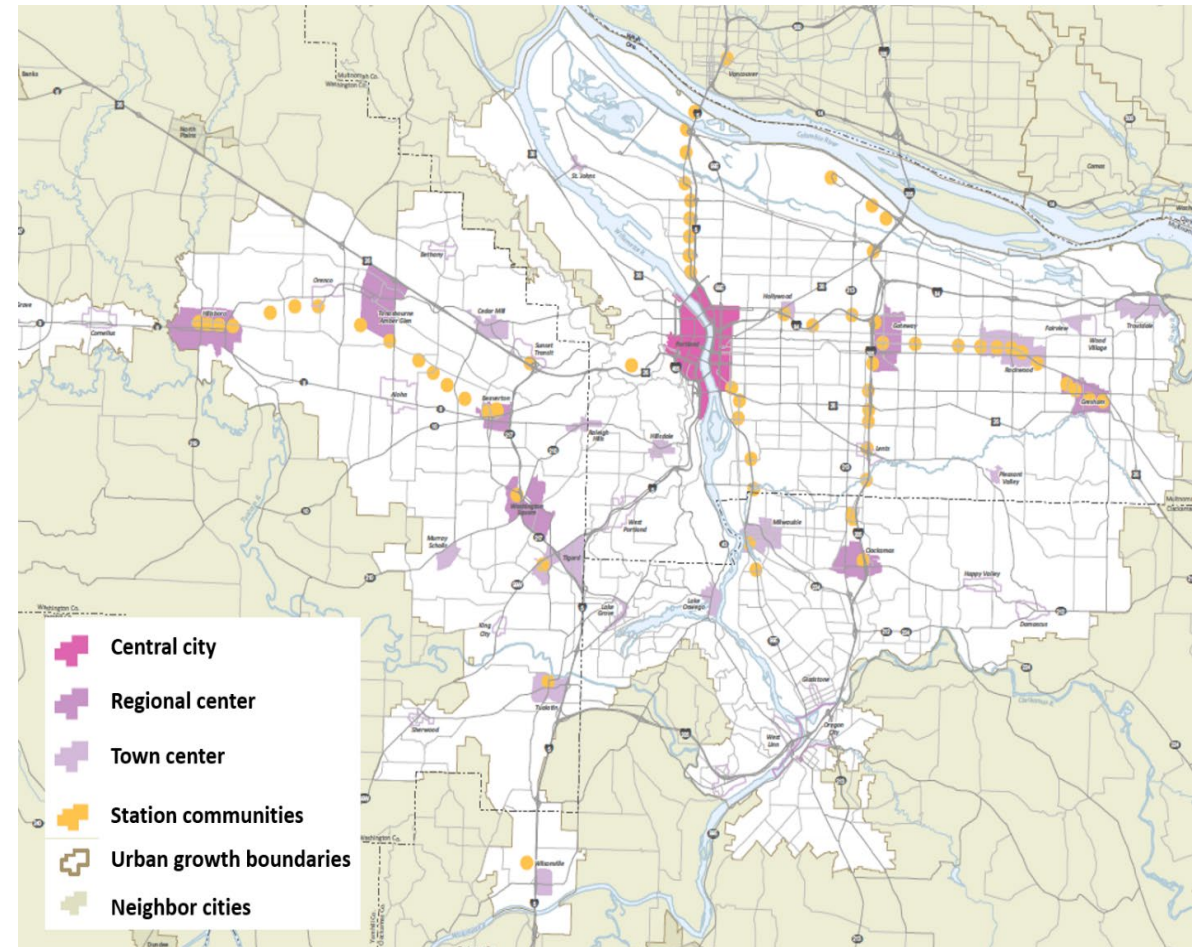




# TOOLS AND STRATEGIES OF PORTLAND METRO

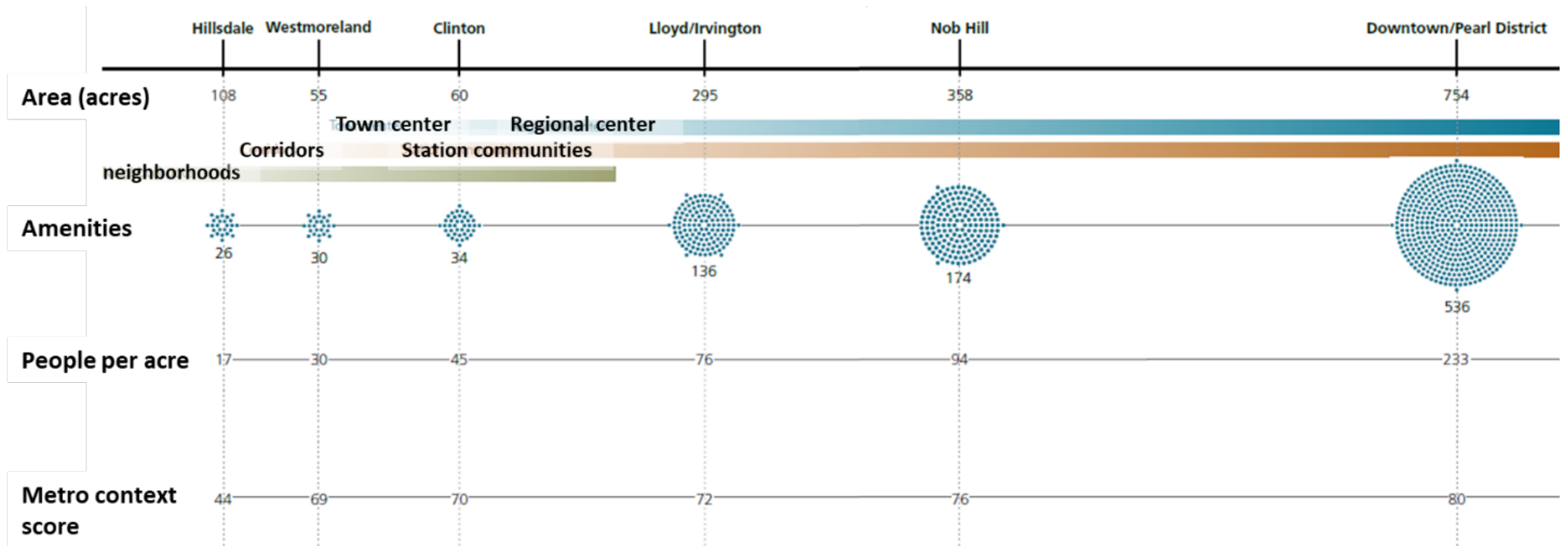
## Urban Growth Management Functional Plan

- 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



# TOOLS AND STRATEGIES OF PORTLAND METRO

- Quantitative indicators by the center hierarchy in the Portland region



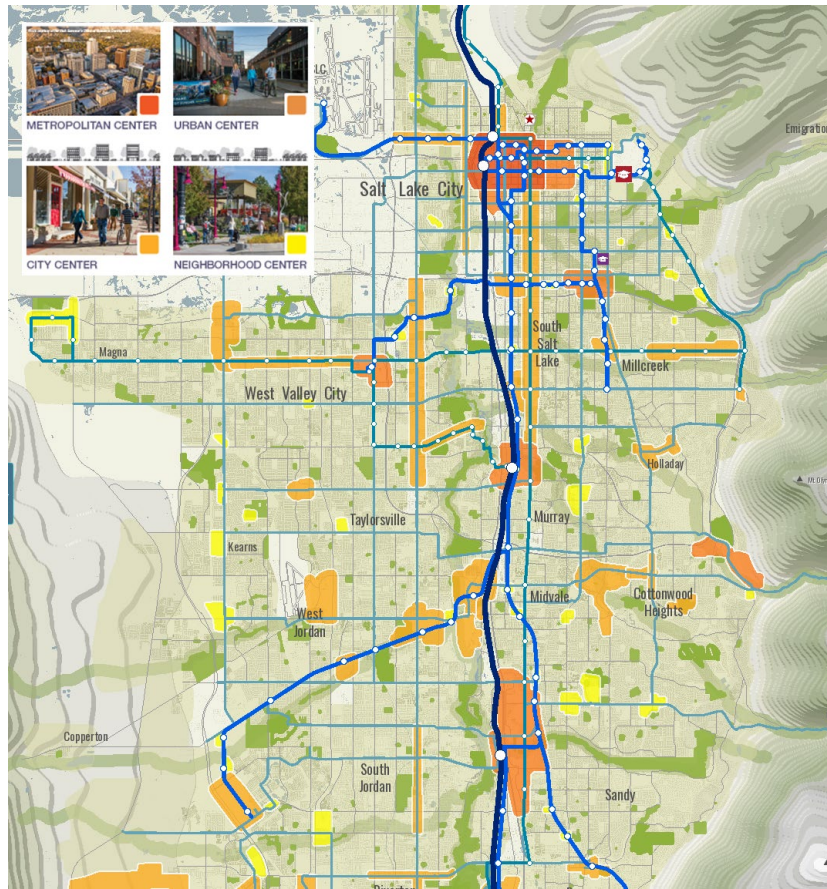


# TOOLS AND STRATEGIES OF PORTLAND METRO

- **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

# CONCLUSION

- A polycentric urban structure has the potential to encourage **smart and sustainable growth**
- Our method and findings could help planners **identify existing and potential centers and establish development guidelines** of centers
- Polycentric development requires **high-quality transit connections** between centers (and a **safe and convenient environment** for active transportation modes), hence coordinated efforts between a transit agency, a metropolitan planning organization, and municipal governments
- **Comprehensive plans of municipalities** are critical to achieving polycentric development as a planning guide for defining future land uses and development.



WASATCH FRONT REGIONAL COUNCIL

# THANK YOU

**Keunhyun Park**

**Department of Landscape Architecture & Environmental Planning**  
**Utah State University**  
[keunhyun.park@usu.edu](mailto:keunhyun.park@usu.edu)

# 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"> <li>1. Job-population balance= <math>1 - \frac{[ABS(\text{employment} - 0.2 * \text{population})]}{(\text{employment} + 0.2 * \text{population})}</math>, where ABS is absolute value of expression in parentheses (Ewing et al., 2015).</li> <li>2. Entropy index= <math>-\frac{[\text{residential share} * \ln(\text{residential share}) + \text{commercial share} * \ln(\text{commercial share}) + \text{public share} * \ln(\text{public share})]}{\ln(3)}</math>, where ln is the natural logarithm.</li> </ol>
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"> <li>1. Intersection density = The number of intersections per square mile</li> <li>2. Percentage of four-way intersection = the number of four-way intersections divided by the total number of intersections</li> </ol>
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"> <li>1. Percentage of regional employment within 10 minutes by car = % of jobs that can be reached within 10-minutes by automobile</li> <li>2. Percentage of regional employment within 30 minutes by transit = % of jobs that can be reached within 30-minutes by transit</li> </ol>
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