A Framework For Integrating Pedestrians into Travel Demand Models

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Intersections Seminar

University of Toronto

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NITC NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES

Portland, Oregon, USA

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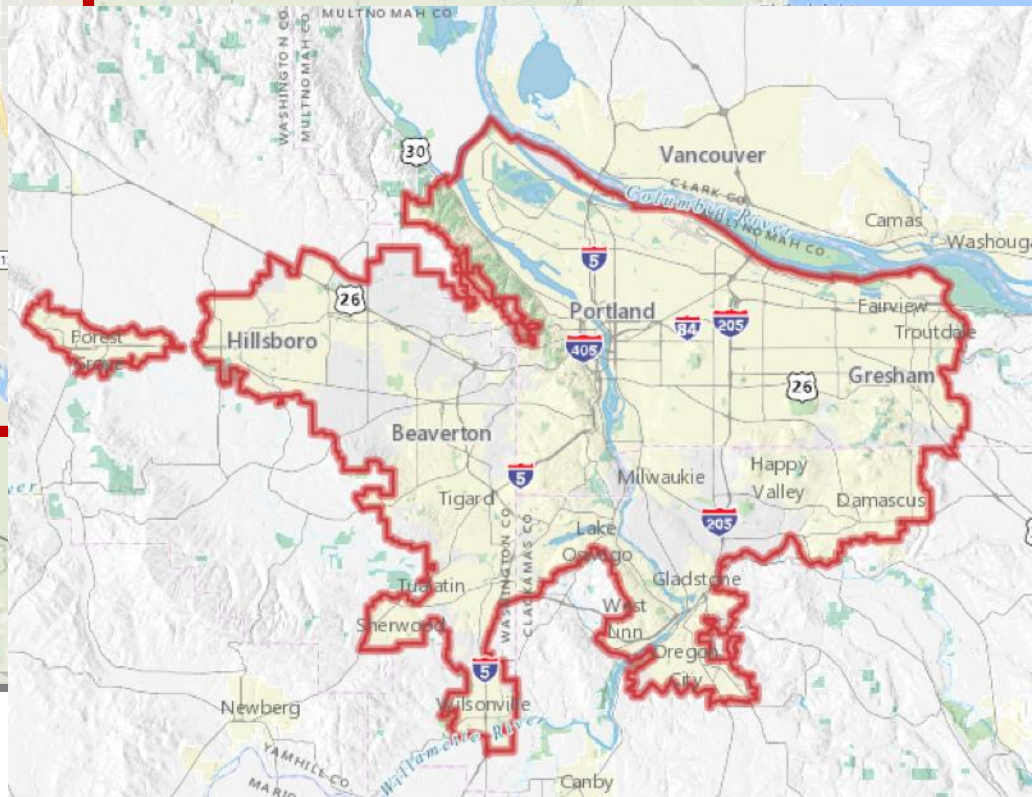
Region

Population~ 2.4 M

Urban Growth Boundary

Only elected regional government in US



Portland, Oregon

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My Research Group

Travel behavior & built environment

- Residential Location
- Active travel
- Planning applications & modelling tools
- Behavioral theory
- Equity
- Assessing transport impacts of new development
- Data collection methods

http://kellyjclifton.com

Outline

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A Framework For Integrating Pedestrians into Travel Demand Models

- Policy & planning context
- Experiences in modeling pedestrians
  - MoPeD – Model of Pedestrian Demand
- What is on the horizon?
  - Behavioral research
  - Data & models
- Next steps

POLICY & PLANNING CONTEXT

Pedestrian modeling outputs

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Direct transportation outputs

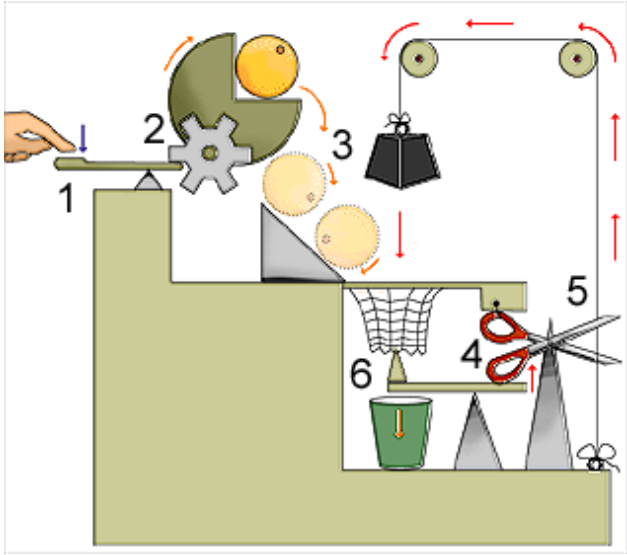
- Walk trips generated
- Walk trips with origins & destinations
- Walk trips with "routes"

  Distances walked

  → Pedestrian miles traveled (PMT)

  Minutes of walking

  → Physical activity levels (METs)



Classified by…

- Geographic location
- Personal characteristics (socio-demographics)

Why model pedestrians?

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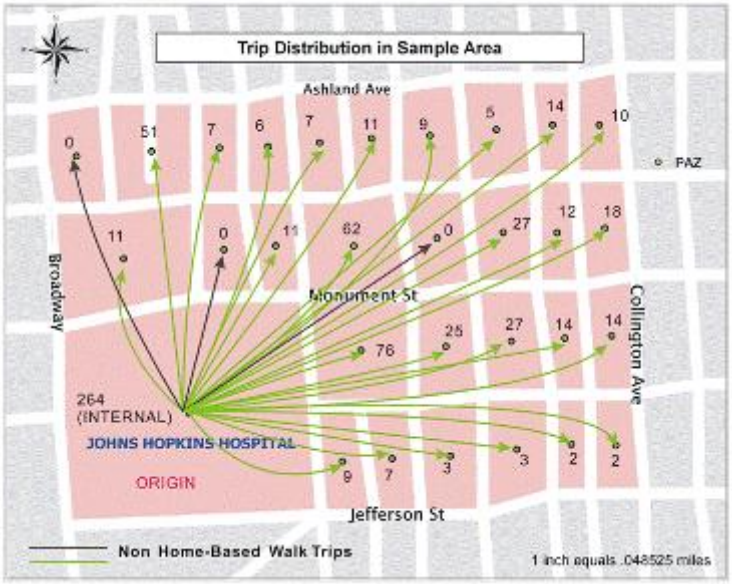
- Pedestrian investments
- Mode shifts
- Greenhouse gas emissions
- Health & safety
- Transit access/egress
- New research opportunities



State of the Practice

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How do travel models estimate walking?

Among 48 large MPOs in US:

- 38% did not estimate walking
- 33% estimated non-motorized (walking + bicycling) travel
- 29% estimated walking

Lacking pedestrian built environment measures & small spatial units

Trip-based model sequence

1. **Generation**
2. **Distribution**
3. **Mode choice**
4. **Assignment**

Source: Singleton, P. A., & Clifton, K. J. (2013). Pedestrians in regional travel demand forecasting models: State-of-the-practice.

Pedestrian modeling applications

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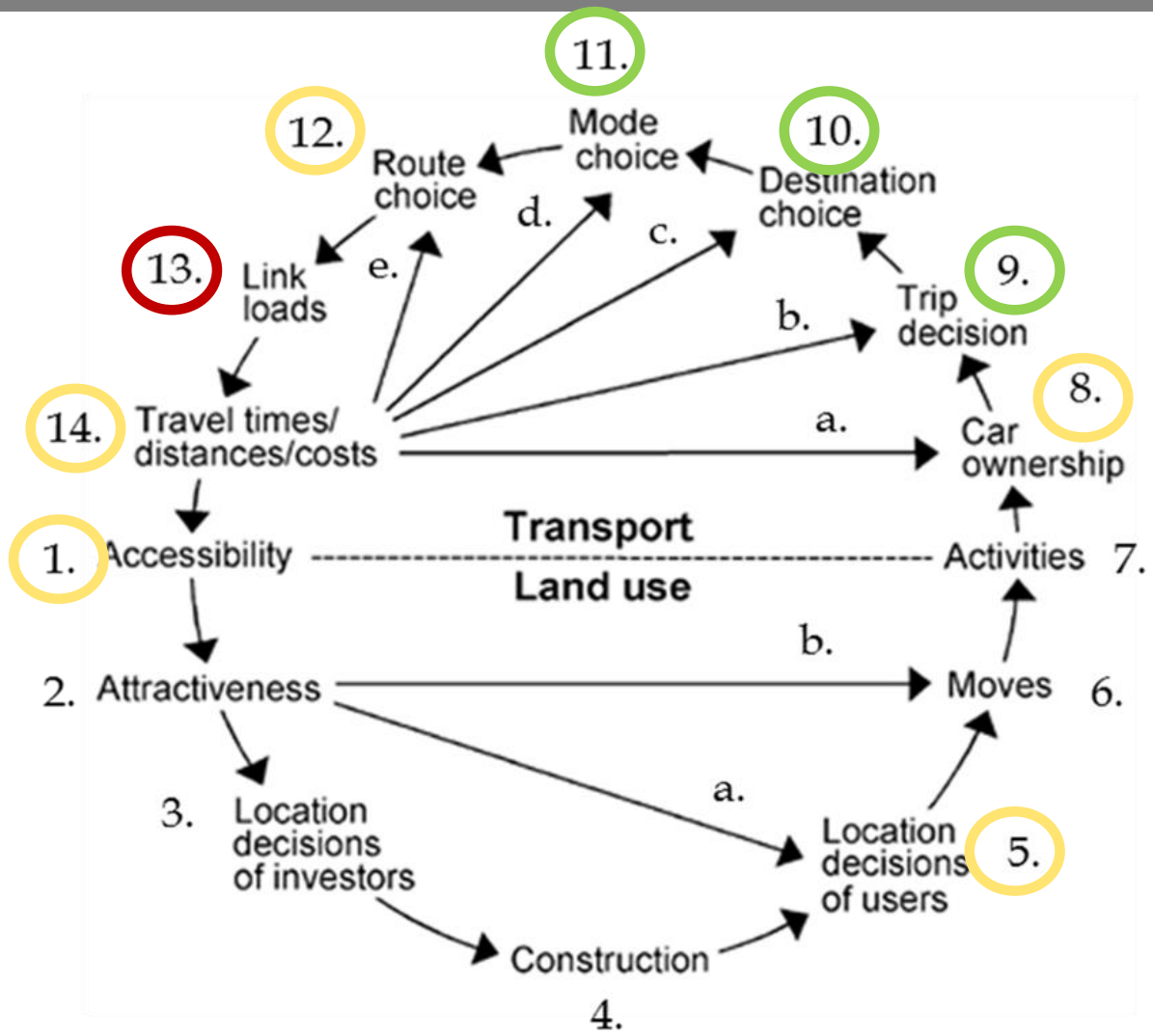
	Currently	*Future interest*
▪ Project prioritization	61% (14)	78% (18)
▪ Scenario planning	43% (10)	65% (15)
▪ Corridor planning	43% (10)	61% (14)
▪ Traffic safety analysis	35% (8)	57% (13)
▪ Health impact assessment	35% (8)	57% (13)
▪ Infrastructure gap analysis	30% (7)	57% (13)

Incorporating pedestrians



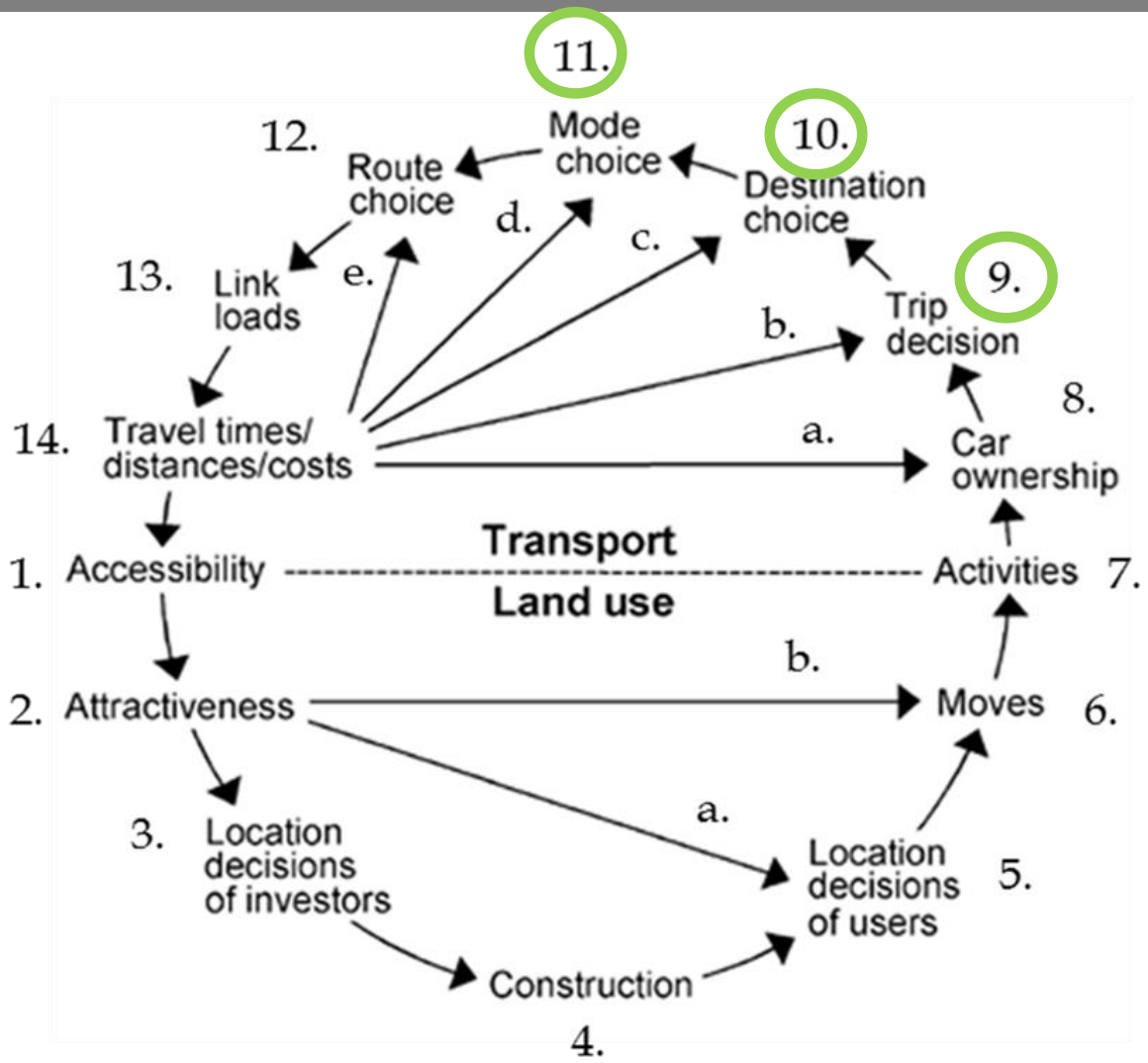
Ready

Challenging

Most Challenging

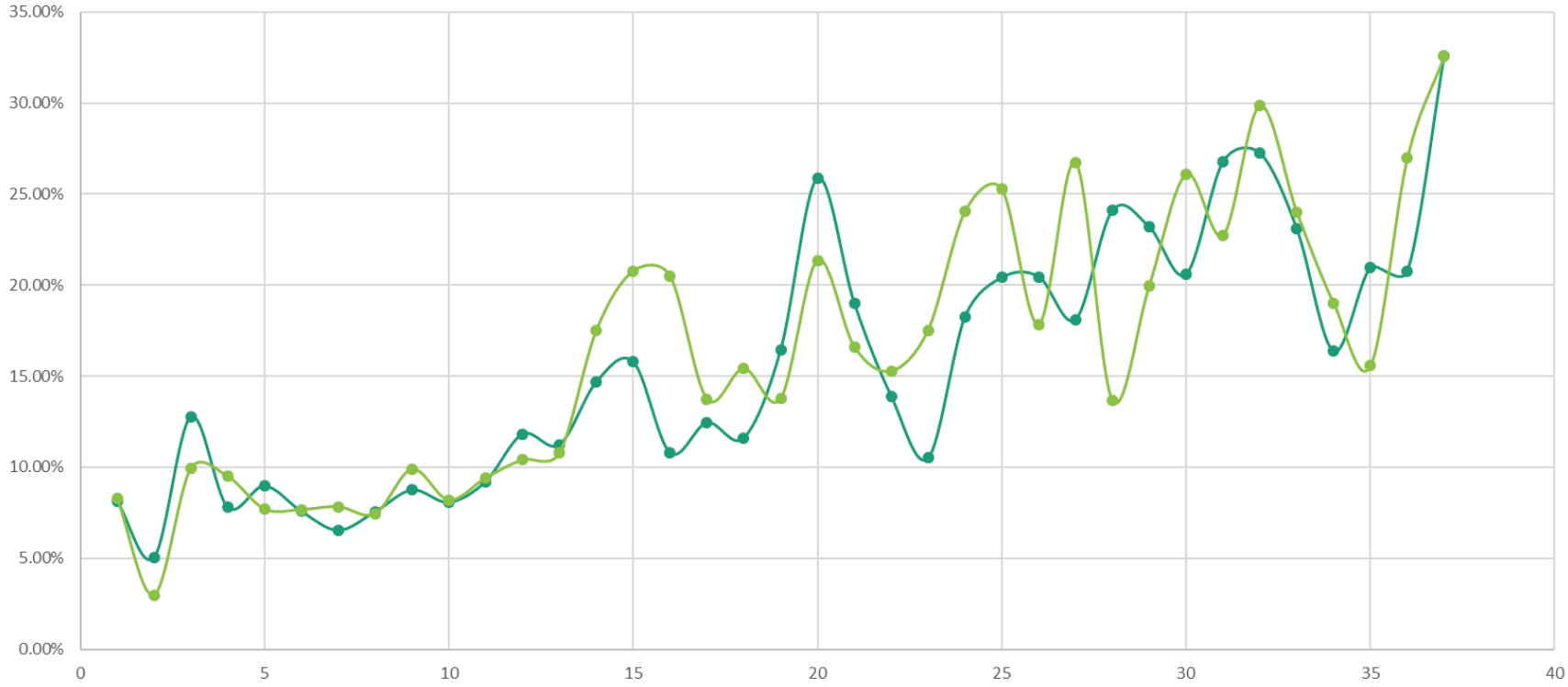
Adapted from: Wegener and Fürst, 1999

Incorporating pedestrians



Ready

Adapted from: Wegener and Fürst, 1999

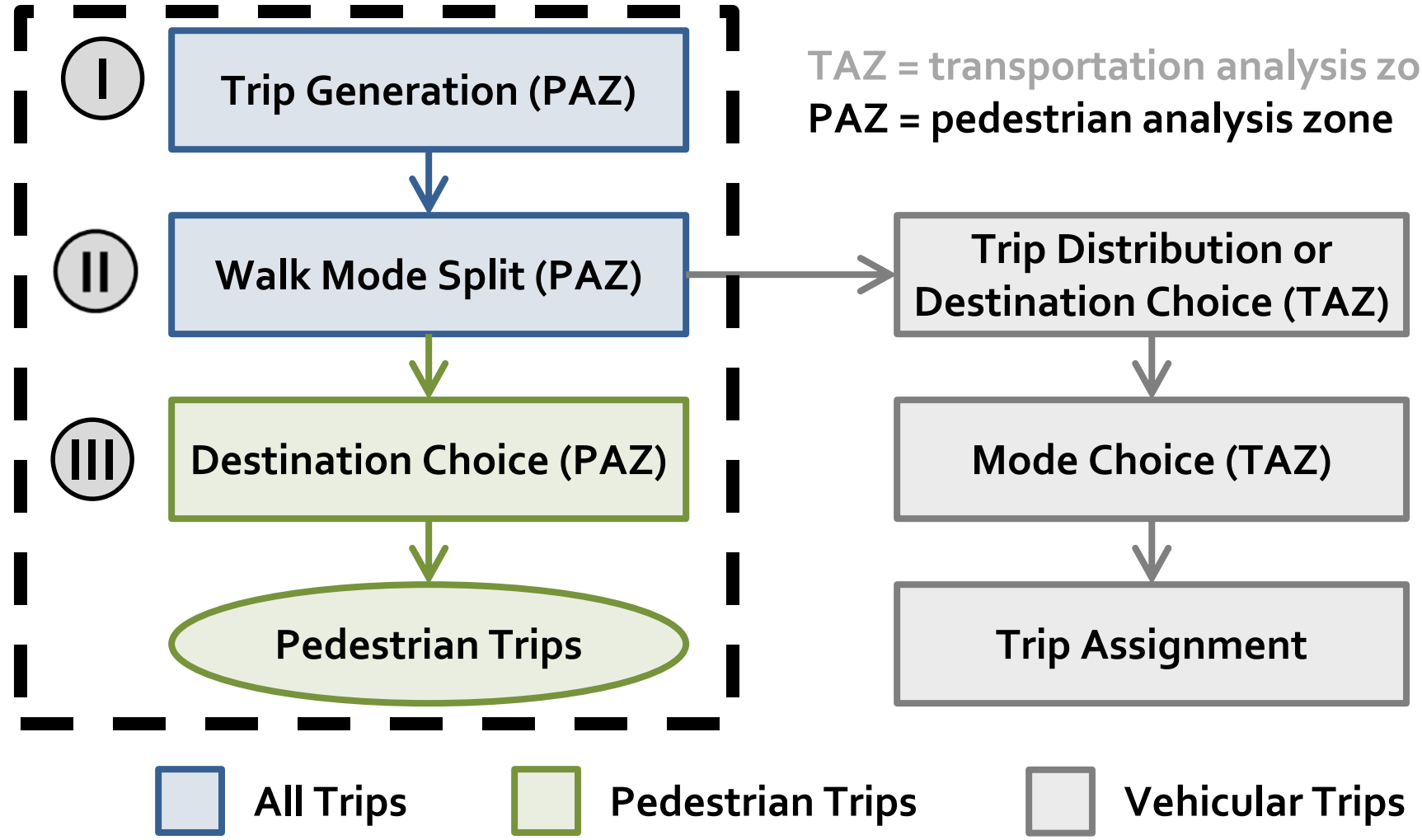


EXPERIENCES IN MODELING PEDESTRIANS - MoPeD

Project overview

- 12 years of research/development in modeling pedestrian demand
- Early work funded by Maryland DOT
  - Pedestrian risk exposure
- Recent research projects funded by NITC and Portland Metro
  - Improve representation of pedestrians in current 4-step method
  - Develop stand alone tool
  - Transferability & forecasting of built environment measures

New MoPeD method



Contributions

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- Nests within current structure but can be used alone
- Pedestrian scale analysis (PAZs)
- Pedestrian-relevant variables (PIE)
- One of the first studies to examine pedestrian destination choice in demand modeling framework
- Highlights policy relevant variables: distance, size, pedestrian supports & barriers

Pedestrian analysis zones

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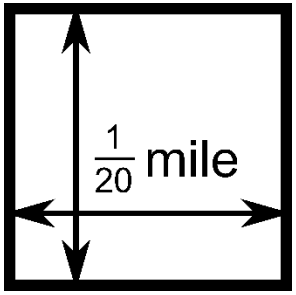

264 feet = 80 m ≈ 1 minute walk

Metro: ~2,000 TAZs → ~1.5 million PAZs

TAZs

PAZs

Home-based work trip productions

Pedestrian environment

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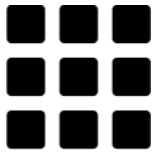
Pedestrian Index of the Environment (PIE)

20–100 score = calibrated ∑(6 dimensions)

People & job density



Block size

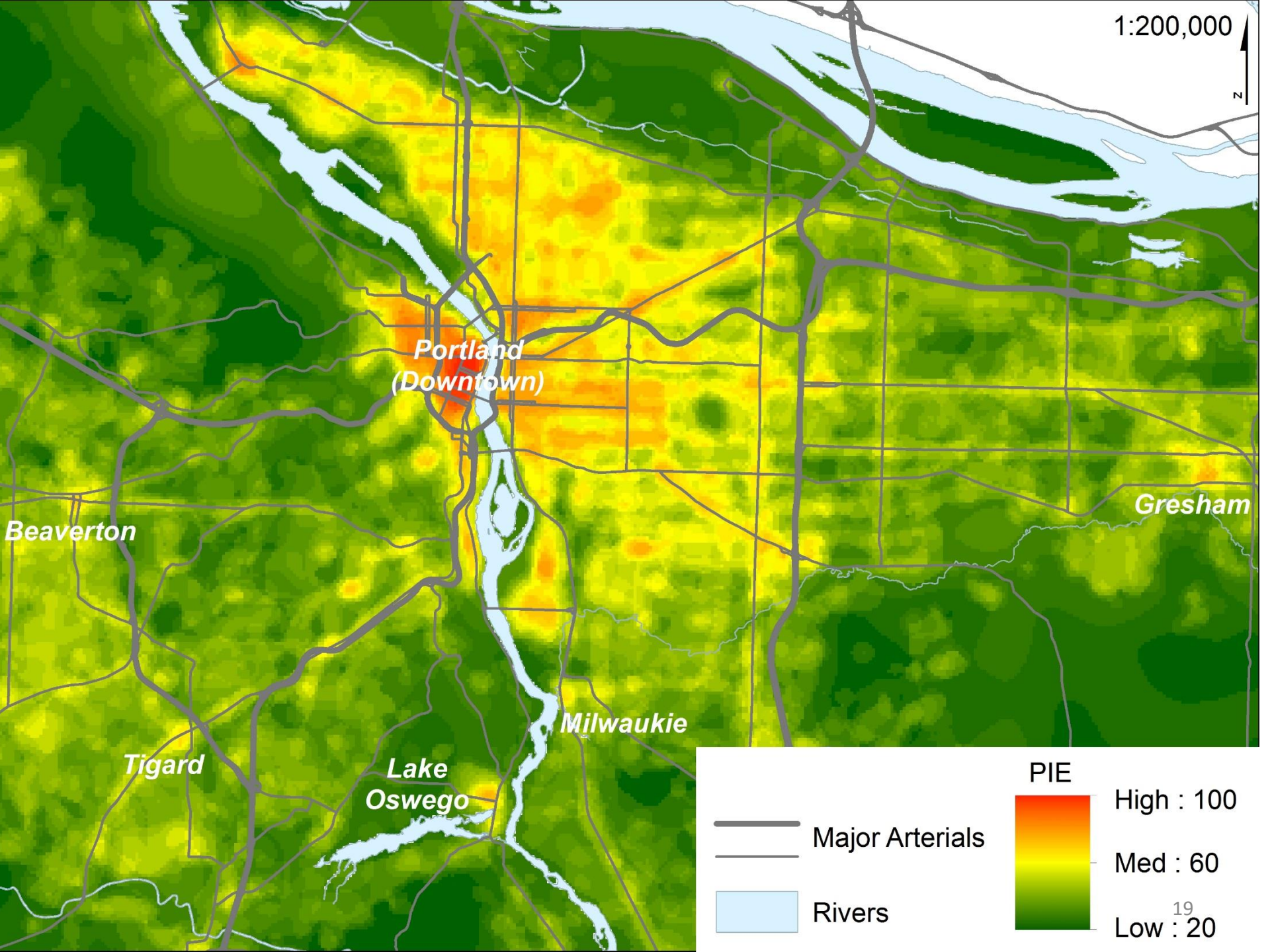
Transit access

Sidewalk extent

Urban living infrastructure

Comfortable facilities

ULI = Urban Living Infrastructure: pedestrian-friendly shopping and service destinations used in daily life.


1:200,000
N
Portland
(Downtown)
Beaverton
Gresham
Milwaukie
Tigard
Lake
Oswego
PIE
High : 100
Med : 60
Low : 20
Major Arterials
Rivers

I Trip Generation

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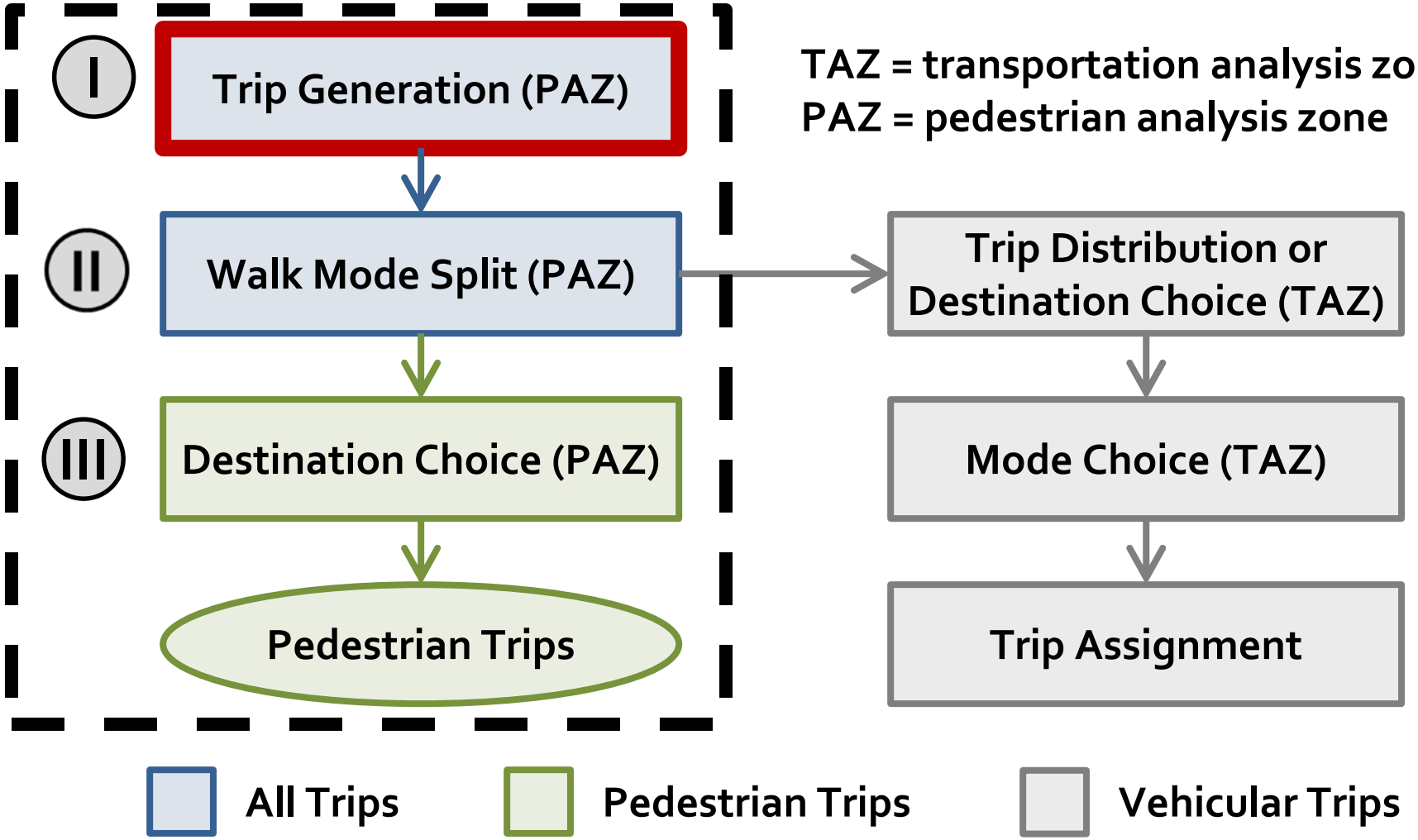

Trip Generation

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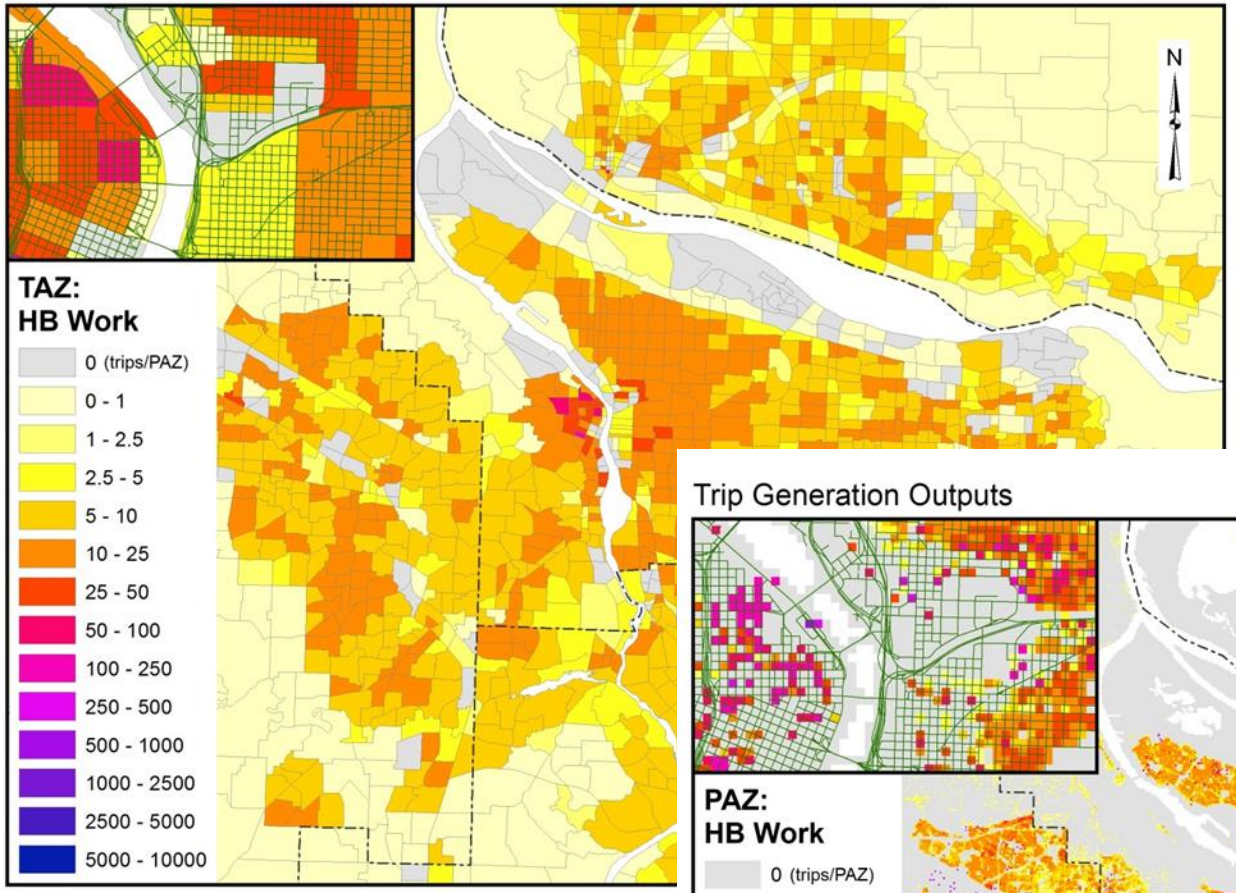
Metro currently has 8 trip production models applied to ~2,000 TAZs:

- HBW – Home-based work;
- HBshop – Home-based shopping;
- HBrec – Home-based recreation;
- HBoth – Home-based other (excludes school and college);
- NHBW – Non-home-based work;
- NHBNW – Non-home-based non-work;
- HBcoll – Home-based college; and
- HBsch – Home-based school.

After testing for scalability, we applied the same models to our pedestrian scale ~1.5M PAZs

Trip Generation Outputs

TAZ Home-Based Work Productions



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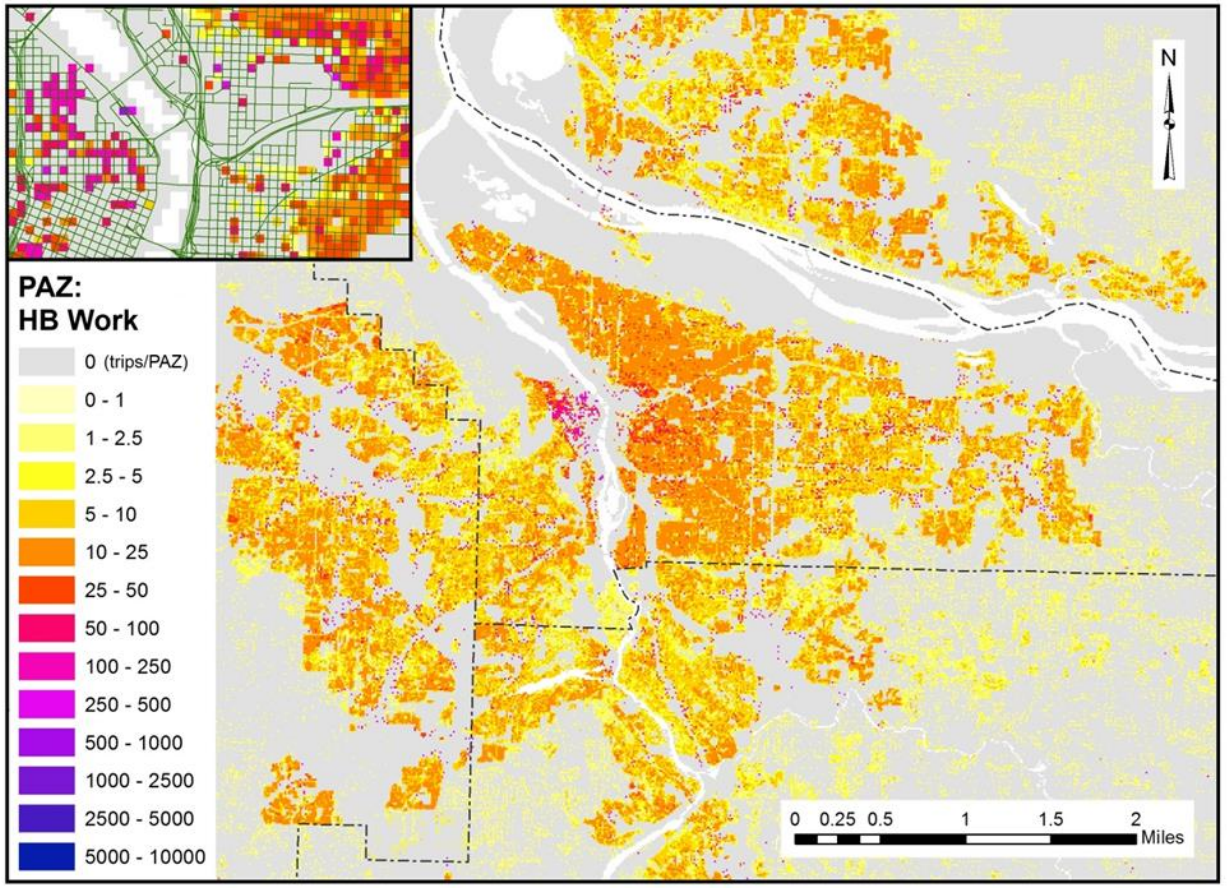
Trip Generation Outputs

PAZ Home-Based Work Productions



II Walk mode split

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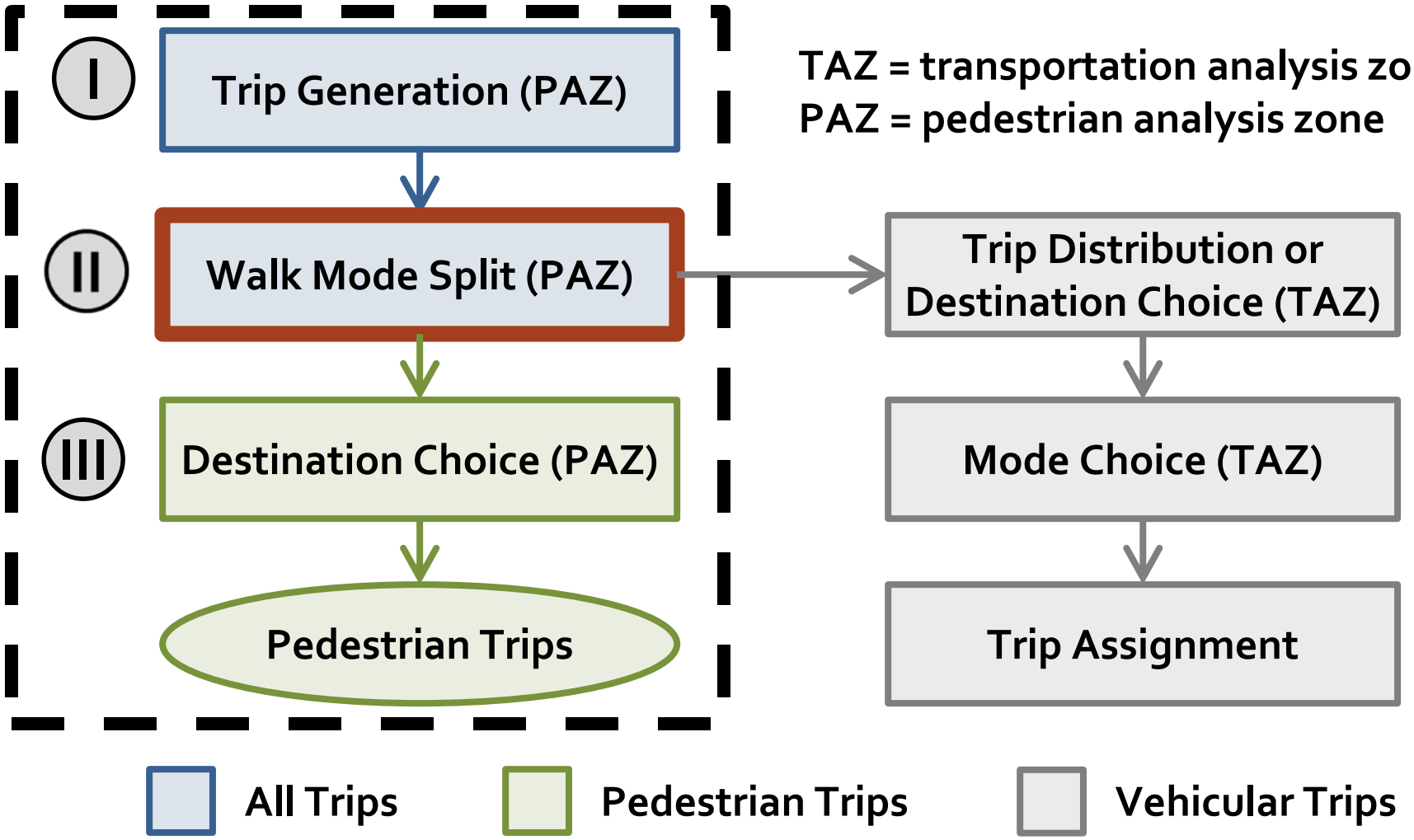
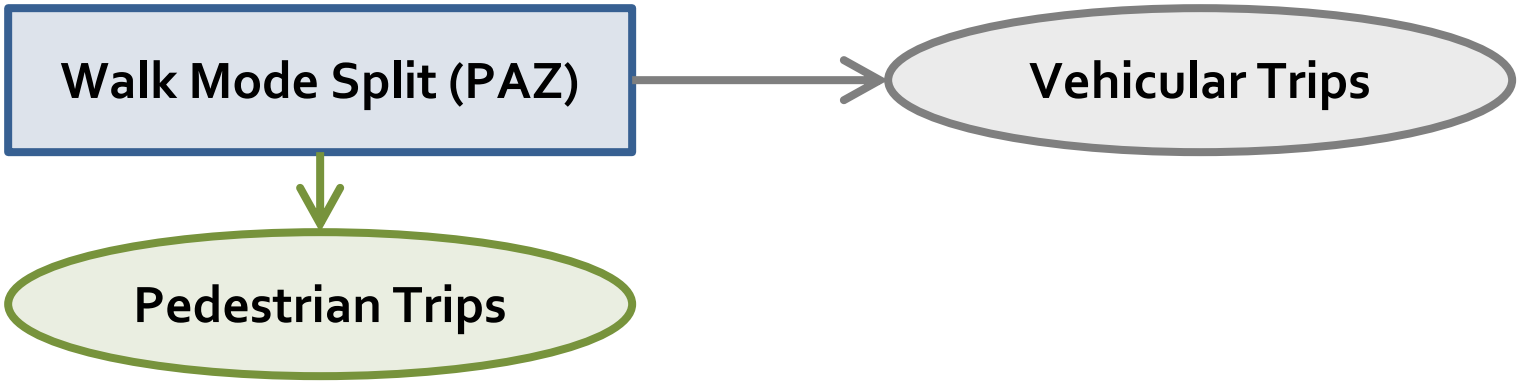


⑪ Walk mode split



Prob*(walk) = *f(traveler characteristics, PIE)

***Data*:**	2011 OHAS, Production trip ends, 90% sample
***Method*:**	binary logit model
***Spatial unit*:**	pedestrian analysis zone (PAZ)

II Walk mode split models

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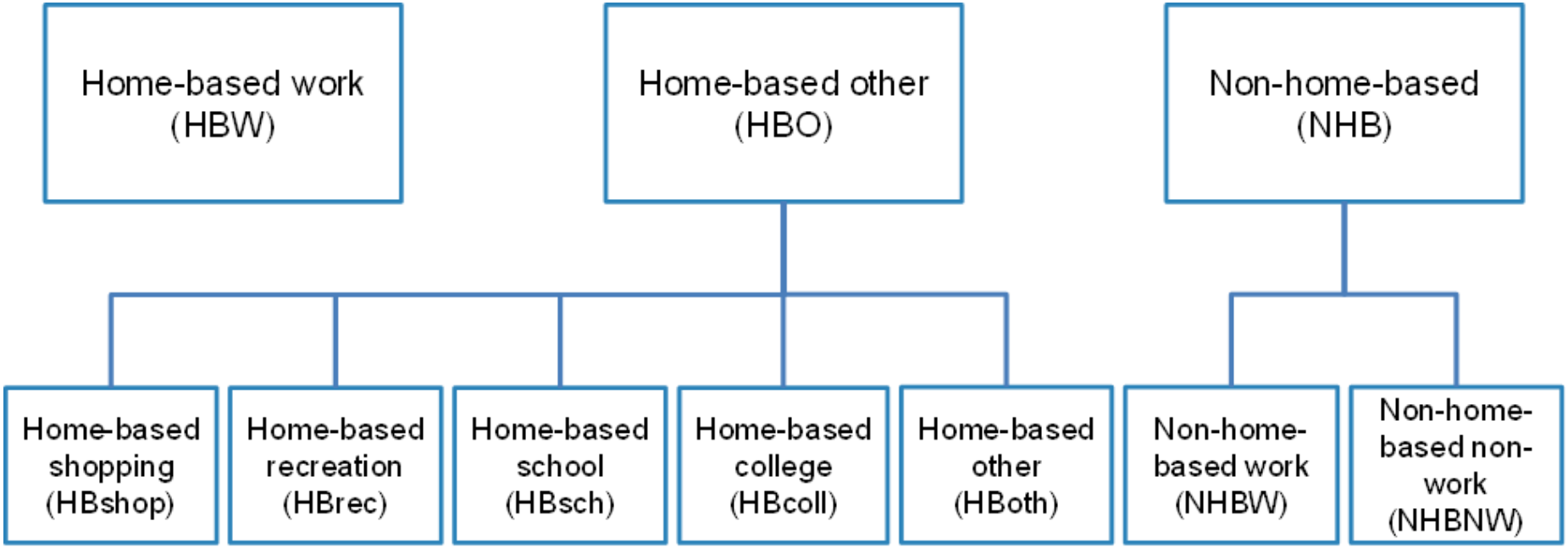

Traveler characteristics: Household size, income, age, # of workers, # children, # vehicles

Built environment: PIE

II Walk model application

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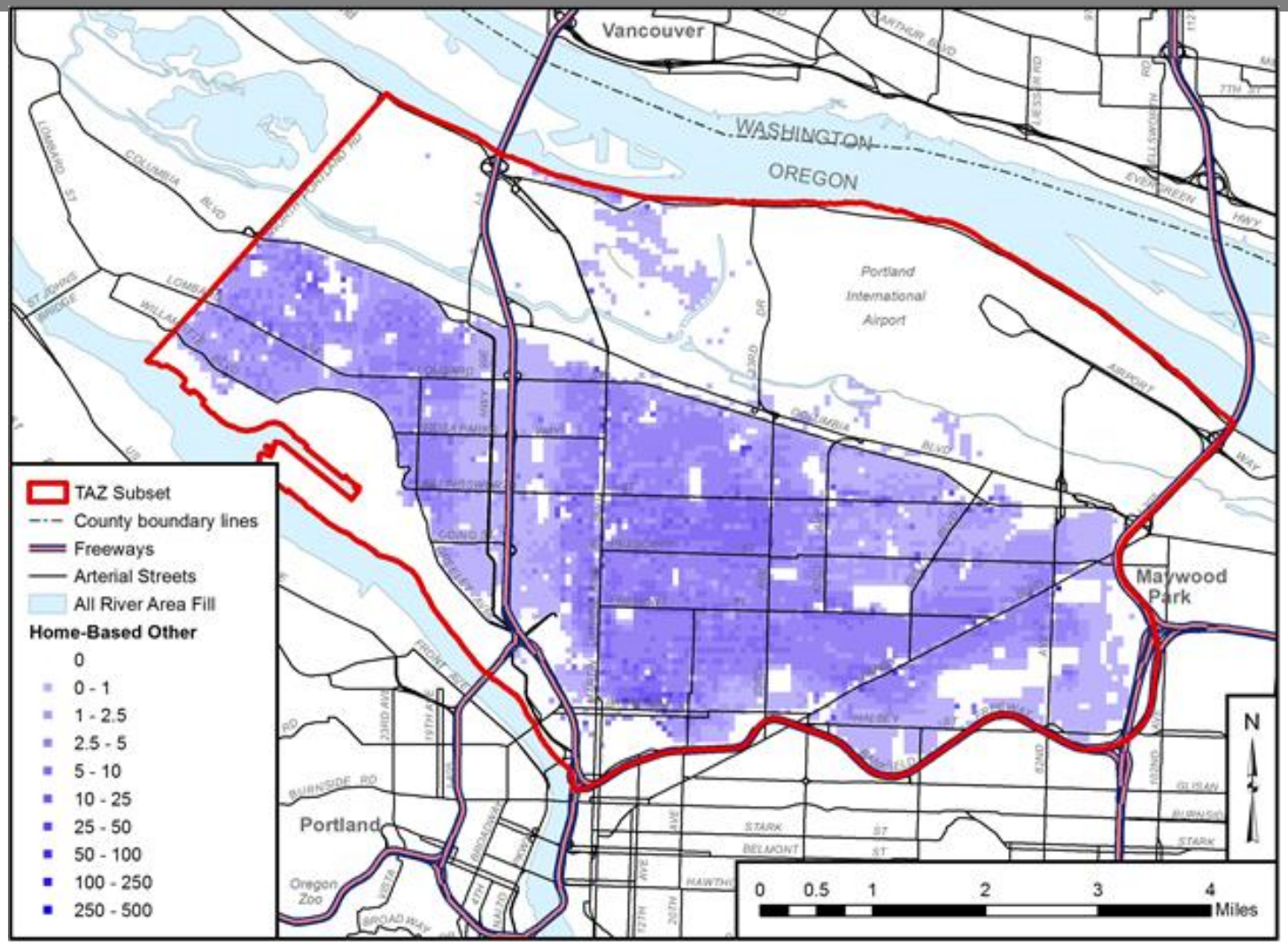

III Destination choice

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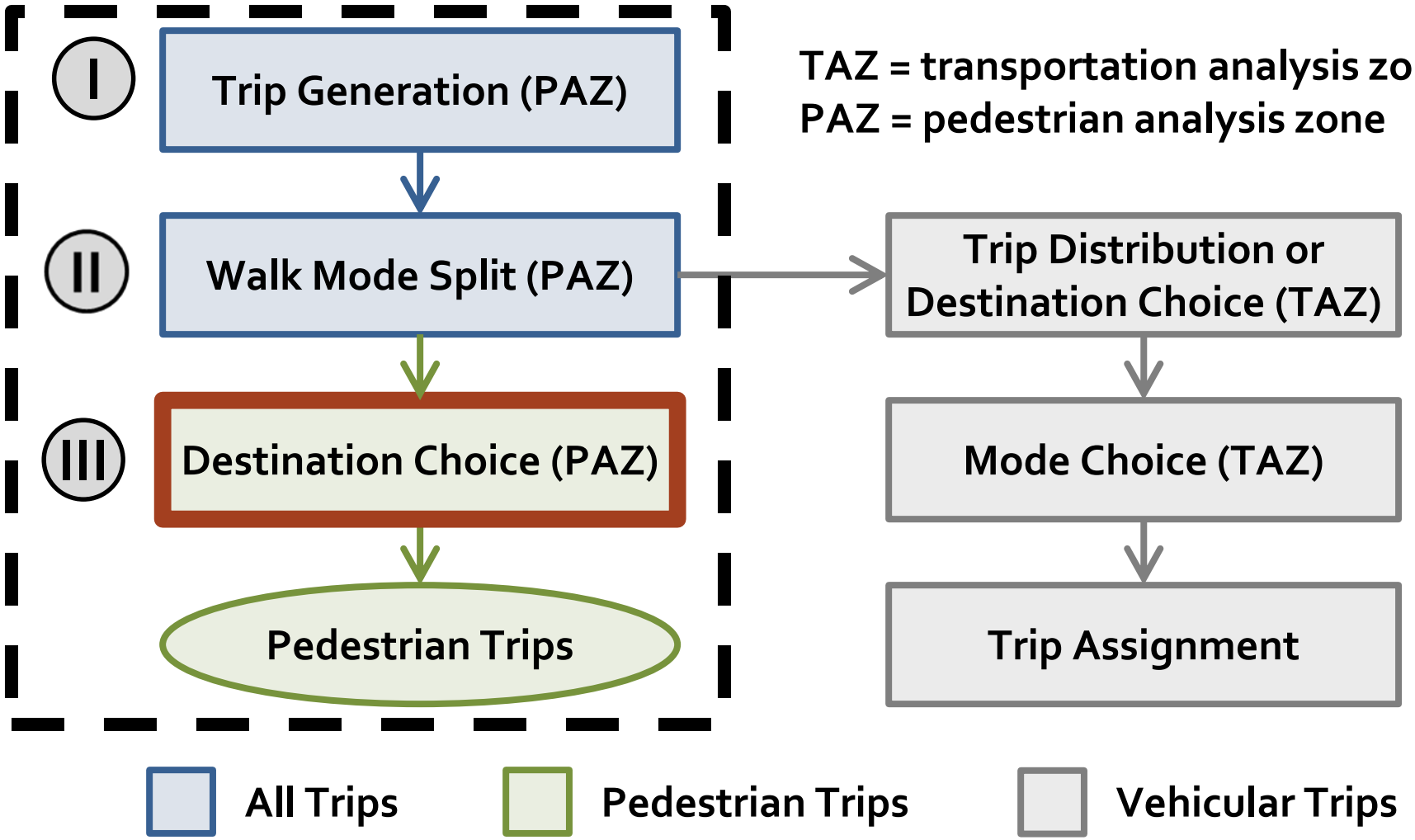
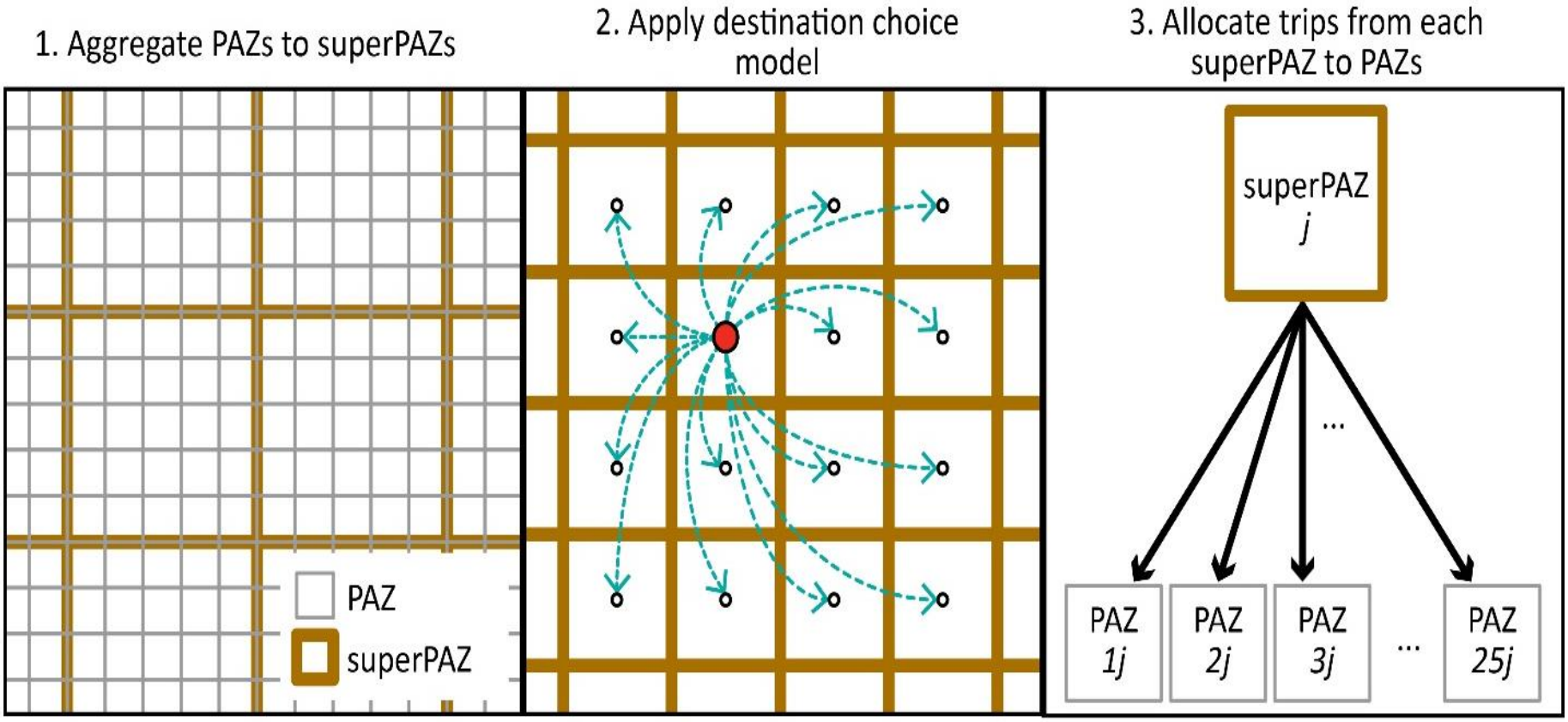


Destination choice



III Destination choice

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***Prob*(dest.) = *function of*…**

network distance, - size / # of destinations

pedestrian environment, traveler characteristics

***Data*: 2011 OHAS**

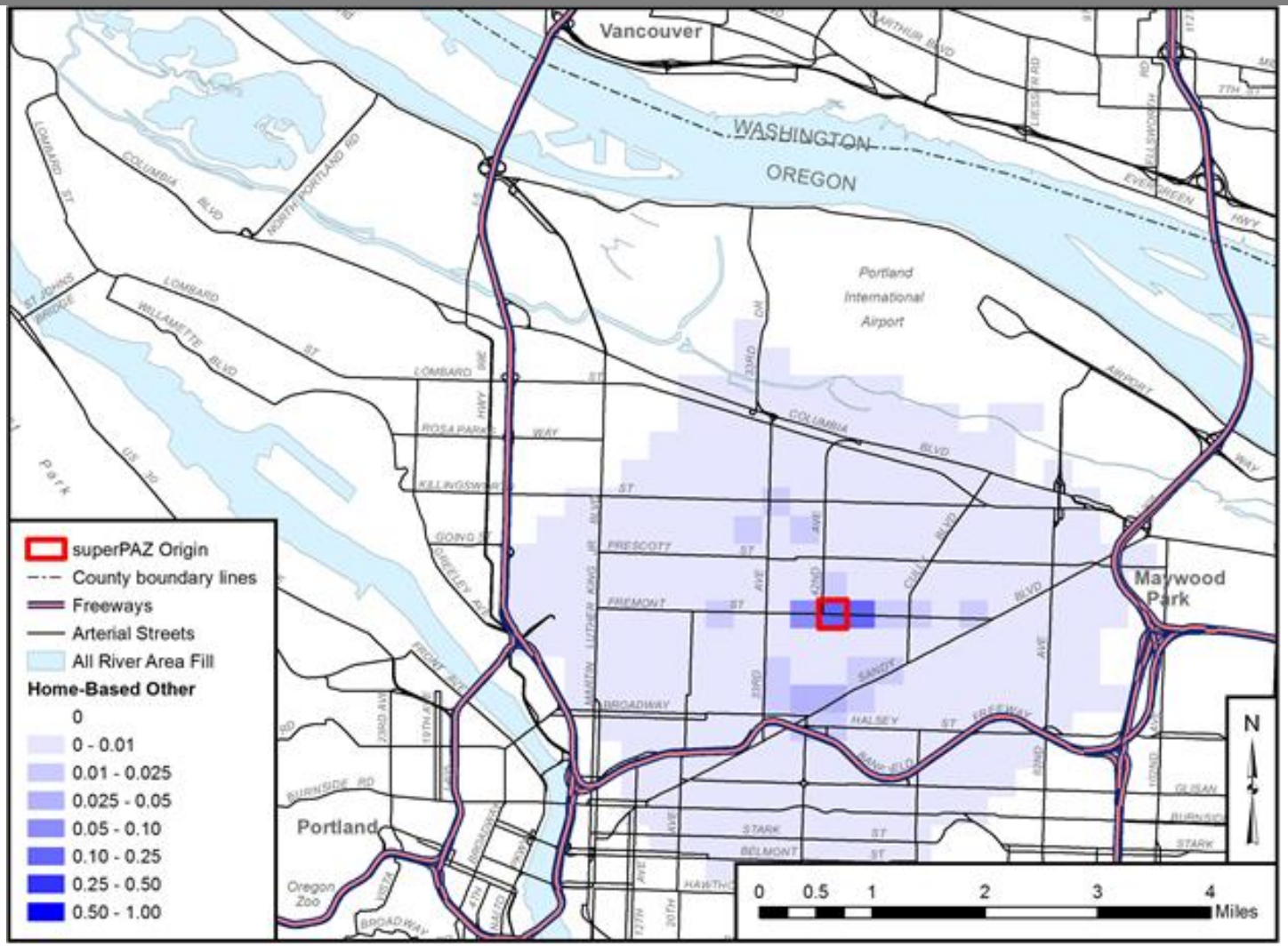
***Method*: multinomial logit model**

***Spatial unit*: super-pedestrian analysis zone**

Six trip types:

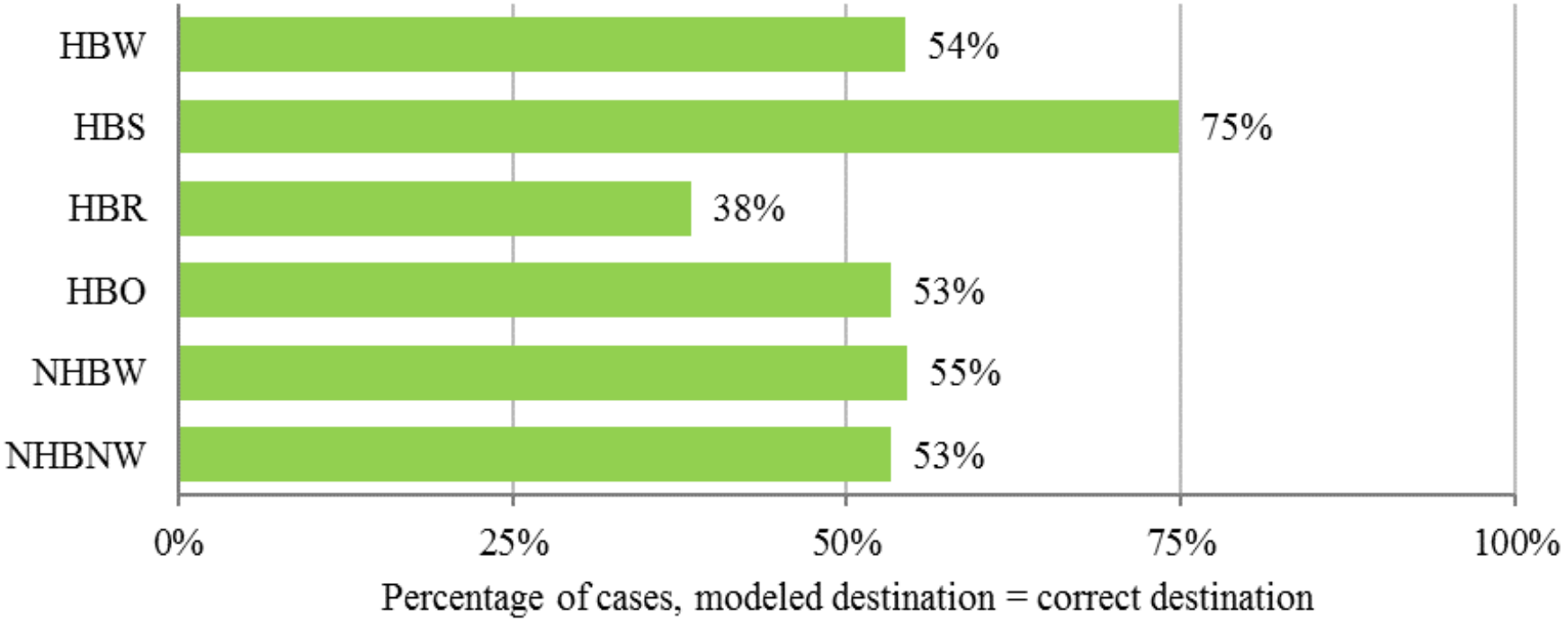
home-based:	non-home-based:
work (HBW)	work (NHBW)
shopping (HBS)	non-work (NHBNW)
recreation (HBR)	
other (HBO)	

Destination Choice



Destination choice

Model Validation – % Correct Destination



Destination Choice

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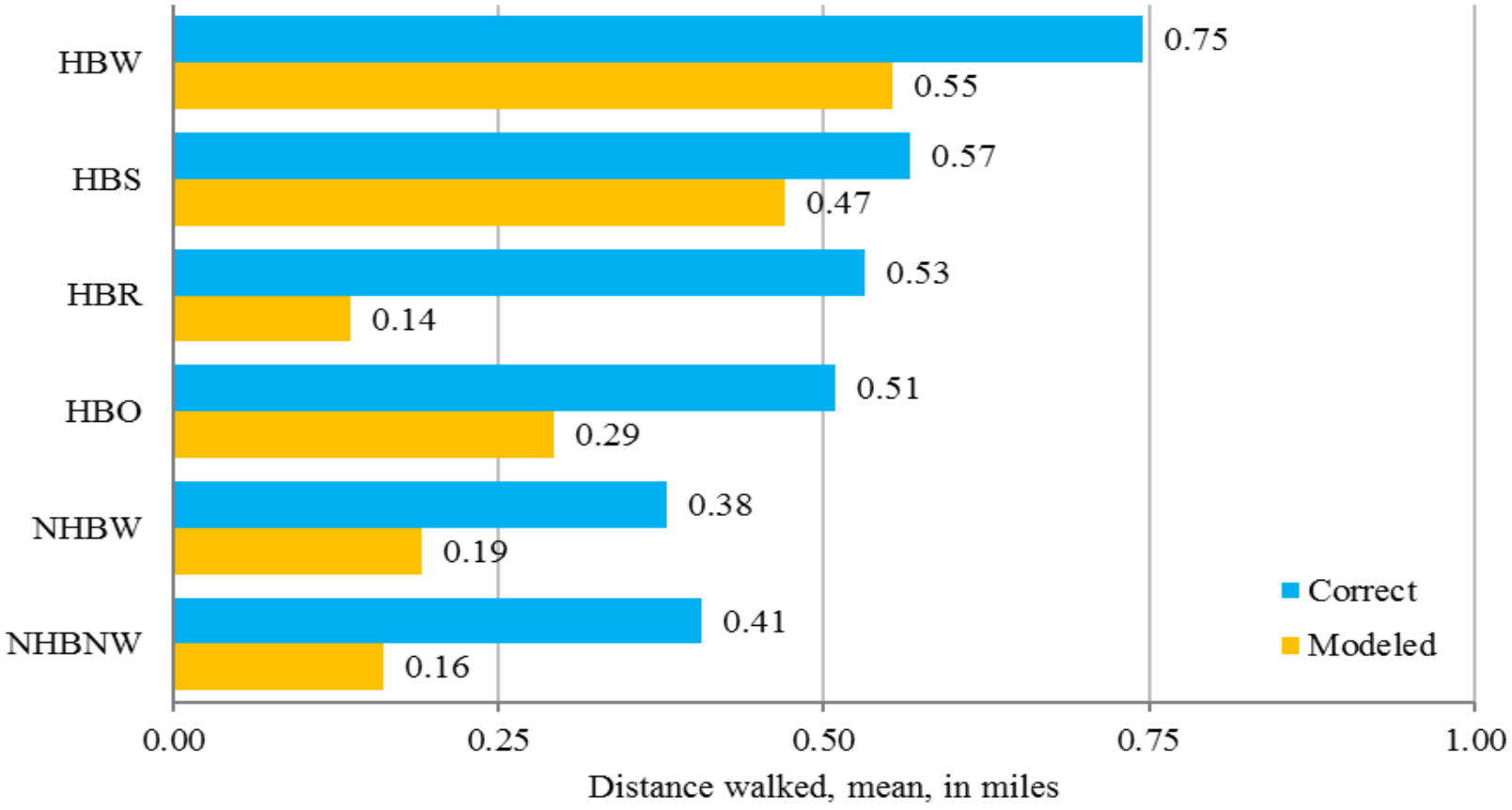
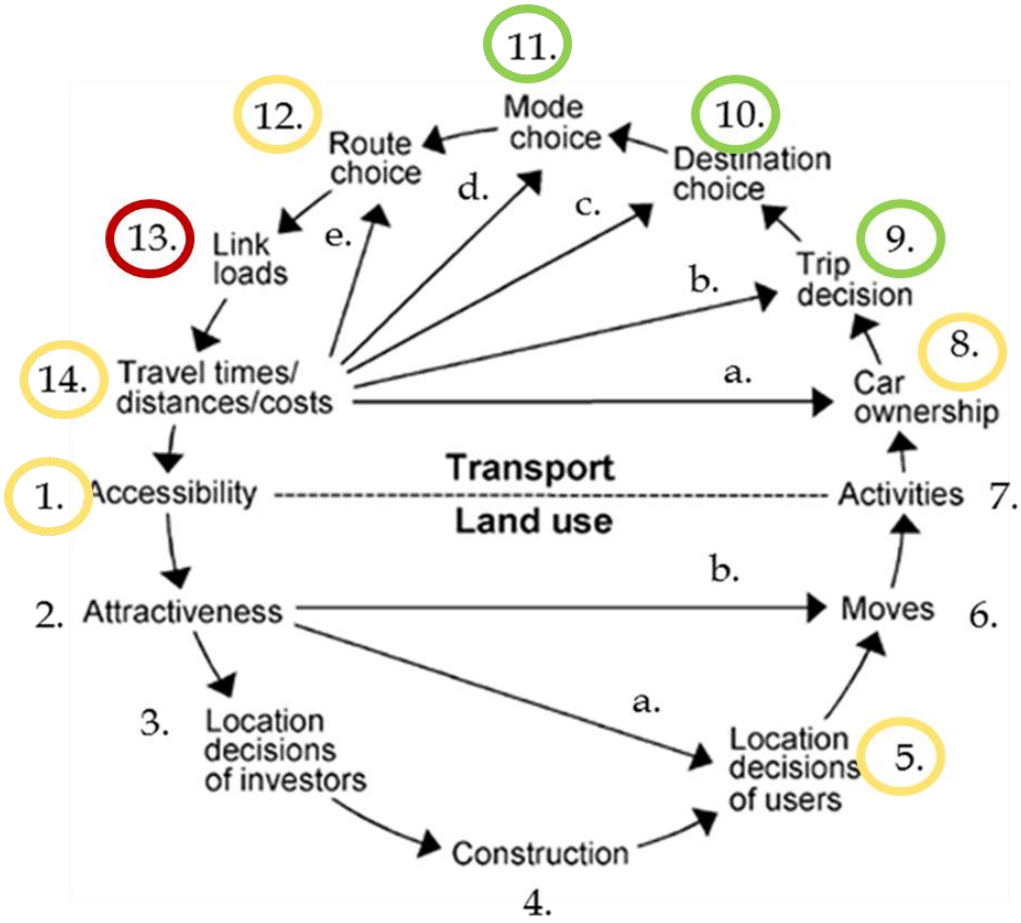
Model Validation – Avg. Distance Walked





Ready

Challenging

Most Challenging

ON THE HORIZON

Behavioral research/data/methods

Adapted from: Wegener and Fürst, 1999

Behavioral research

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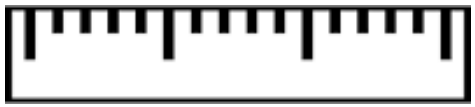
Decision sequencing:

activity, mode, destination;
mode, destination, activity;
destination, activity, mode

Destination choice considerations

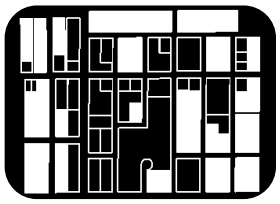
– choice set generation

Willingness to walk



Path/route choice considerations

Behavioral Research



Built environment

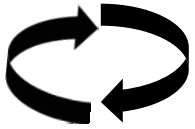
- Thresholds & nonlinearities
- Mixing
- Scale

Lifestyle questions:

- Vehicle ownership & residential location
- Attitudes, motivations & values

Positive Utility of Travel

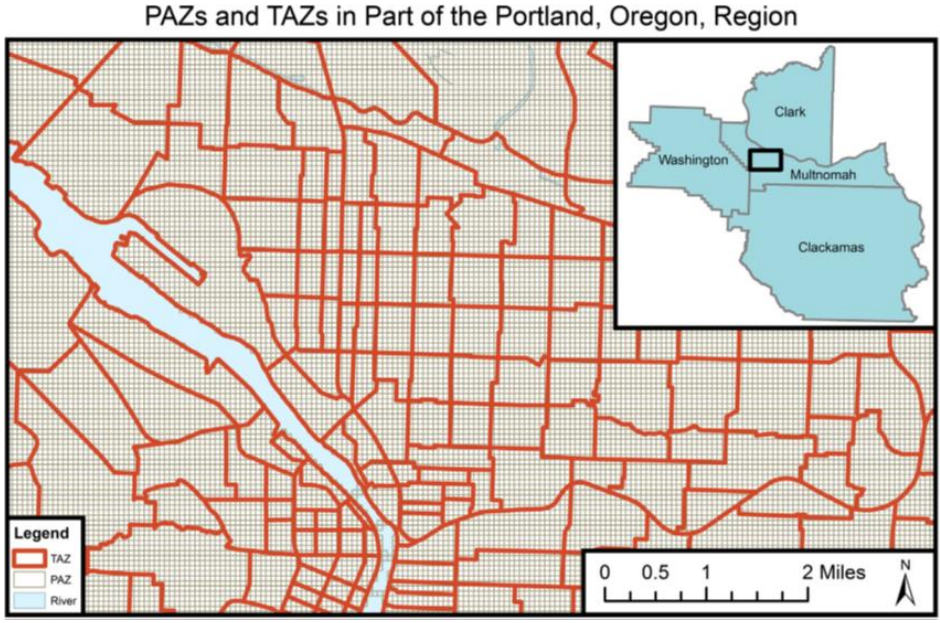
- What aspects?
- Diminishing returns?



Mode feedbacks to trip generation

Spatial/Temporal Scale

- How much detail do we need?
- Depends on output needed for policy/research
- Capture variations in the pedestrian built & natural environment
- Spatial accuracy
- Theory/Behavior



Fixed Scales

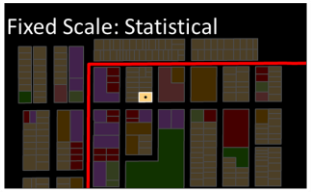
- Administrative
- Statistical
- Artificial

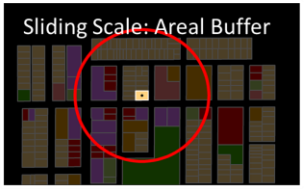
Sliding Scales

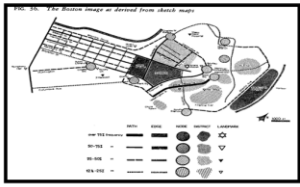
- Areal Buffer
- Network Buffer
- Activity Space

Perceptive Scales

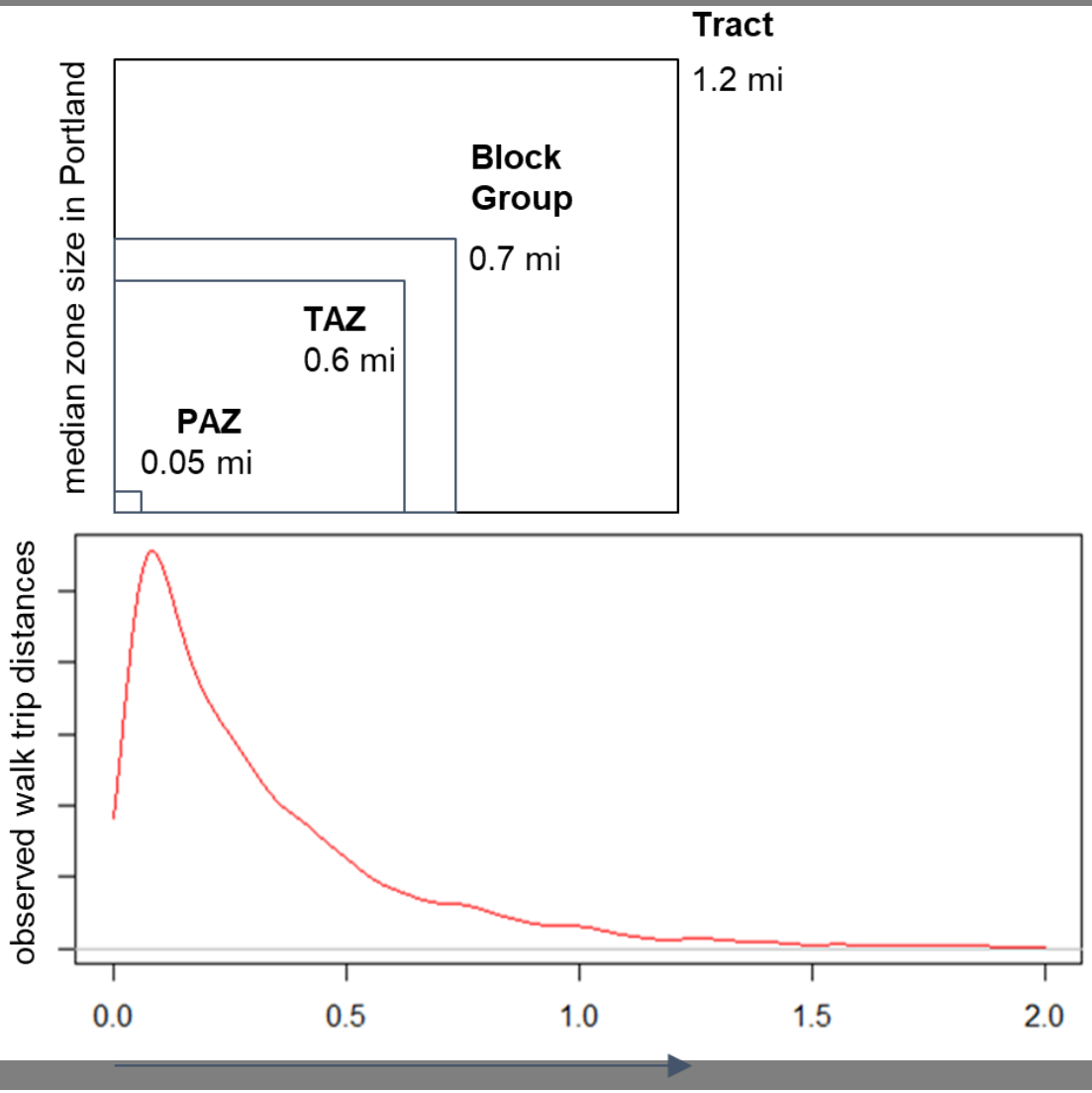
- Mental Maps





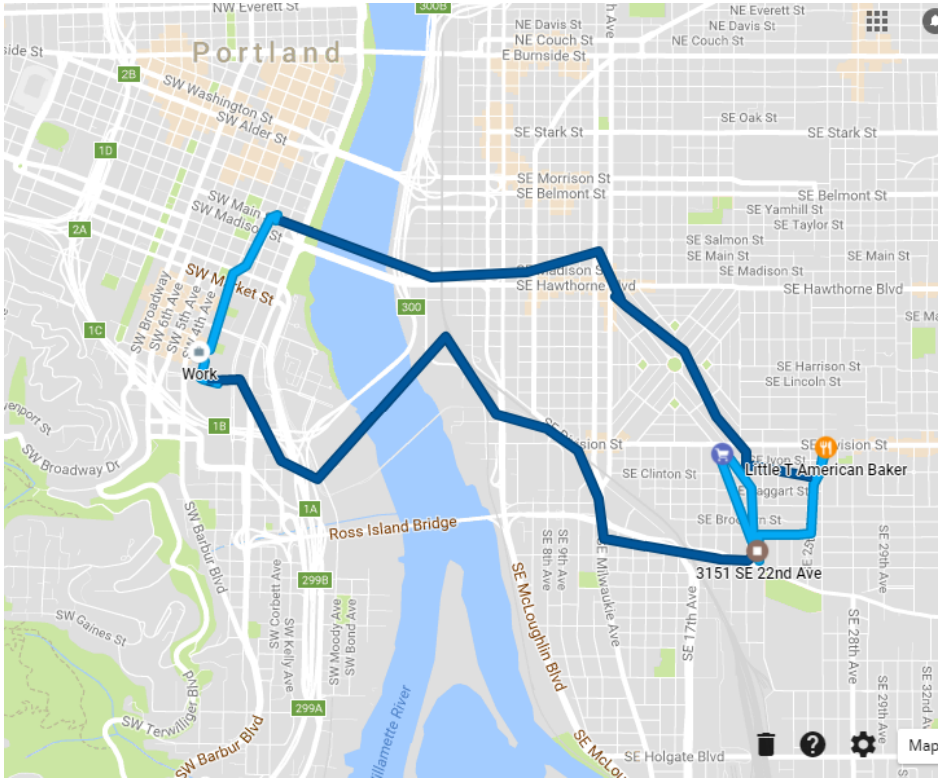


Trip distance & scale

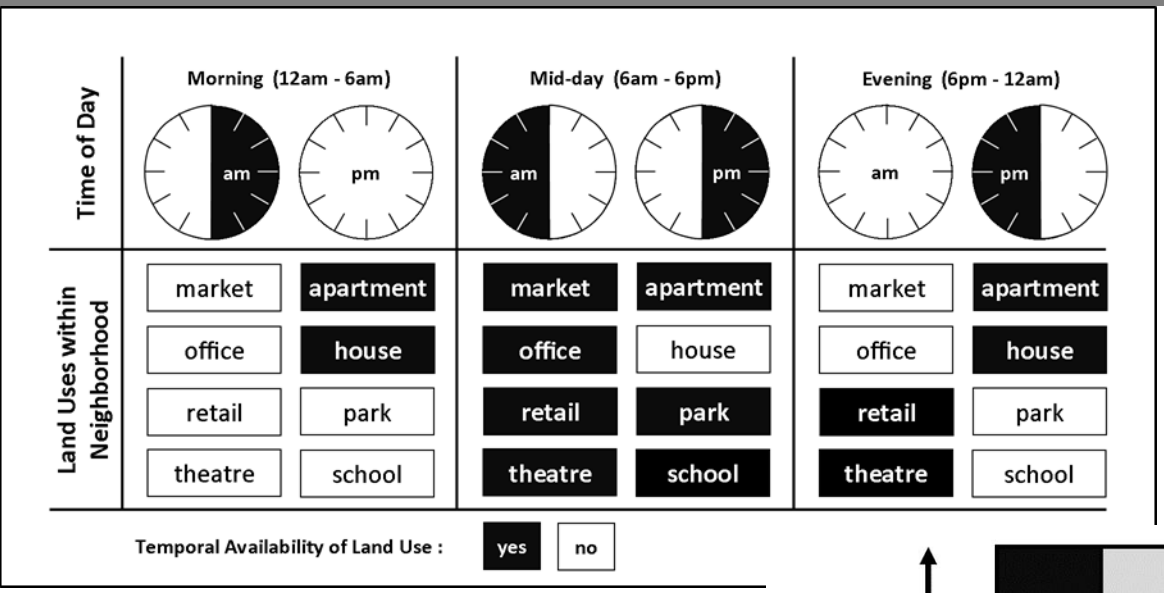


Walking Behavior

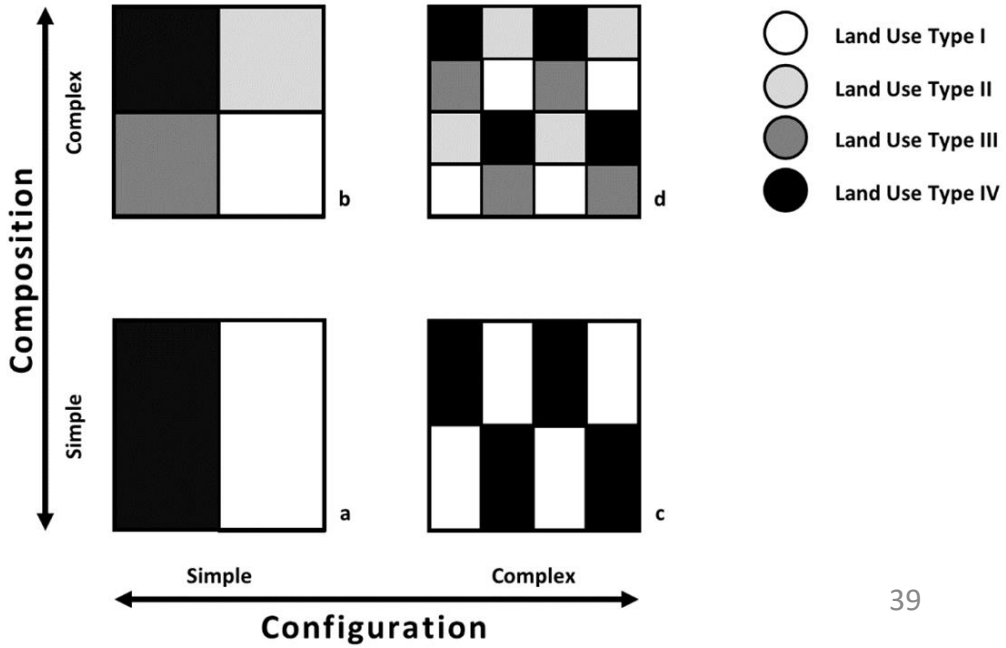
- Passive data sources
  - Trip-level information
  - Multi-day
  - Multi-modal
  - Destinations
  - Routes & speeds
- But also need…
  - Motivations & considerations
  - Barriers
  - Trips not made



Built environment



- How & what to represent?
- Indices, proxies
- Forecasting

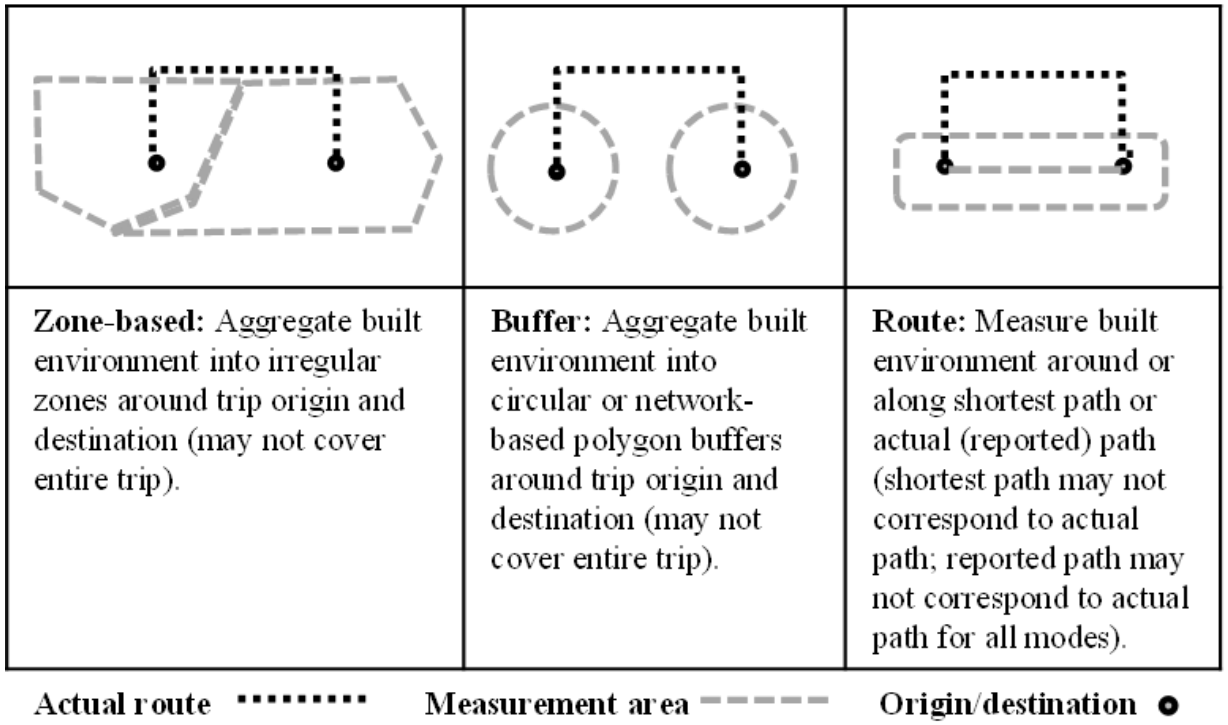


S.R. Gehrke, & K.J. Clifton. (2016). Toward a spatial-temporal measure of land-use mix. *Journal of Transport and Land Use, 9(1):171–186*

S.R. Gehrke, & K.J. Clifton. (2014). Operationalizing land use diversity at varying geographic scales and its connection to mode choice: Evidence from Portland, Oregon. *Transportation Research Record: Journal of the Transportation Research Board* 2453: 128-136.

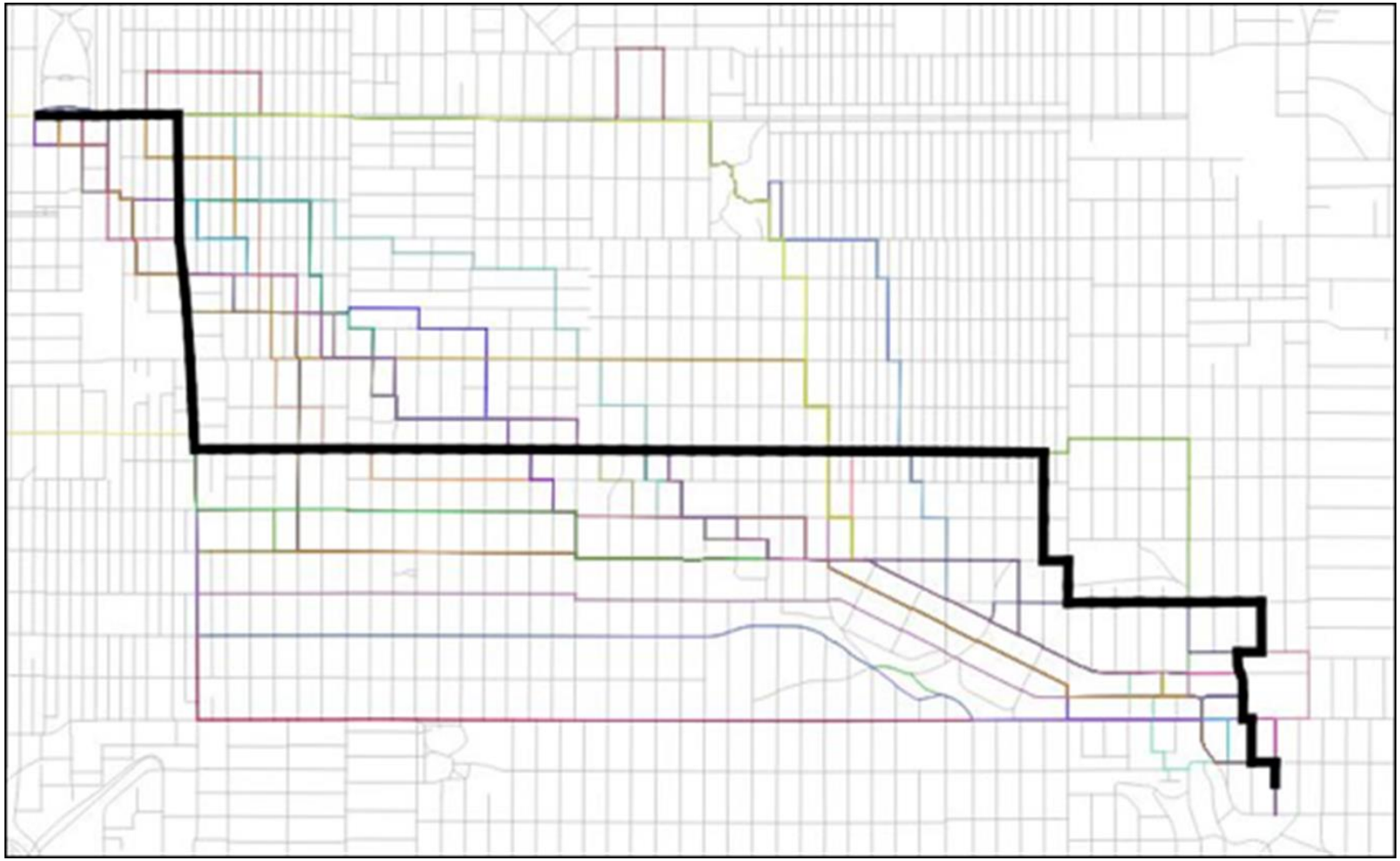
Networks

- Network representation
- How do we attribute networks?
- Feedbacks of travel costs



Broach, J. P. (2016). *Travel mode choice framework incorporating realistic bike and walk routes* (Order No. 10061477). Available from Dissertations & Theses @ Portland State University; ProQuest Dissertations & Theses Global.

Network assignment?



Validation

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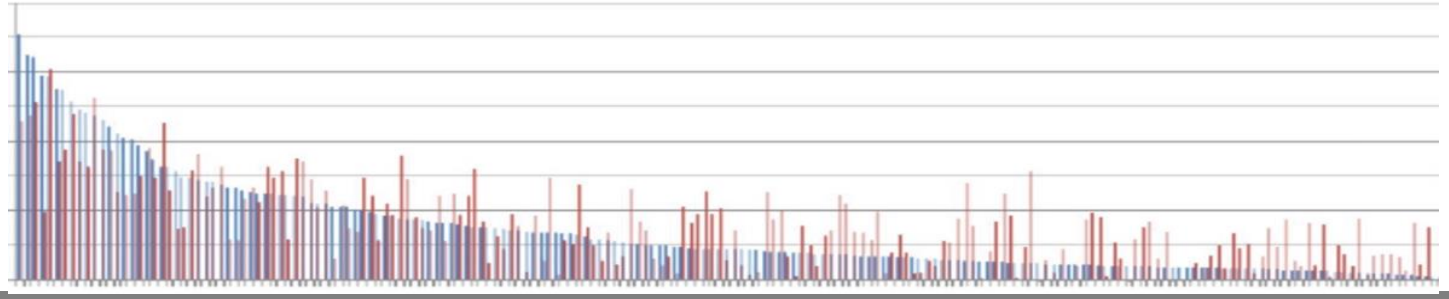
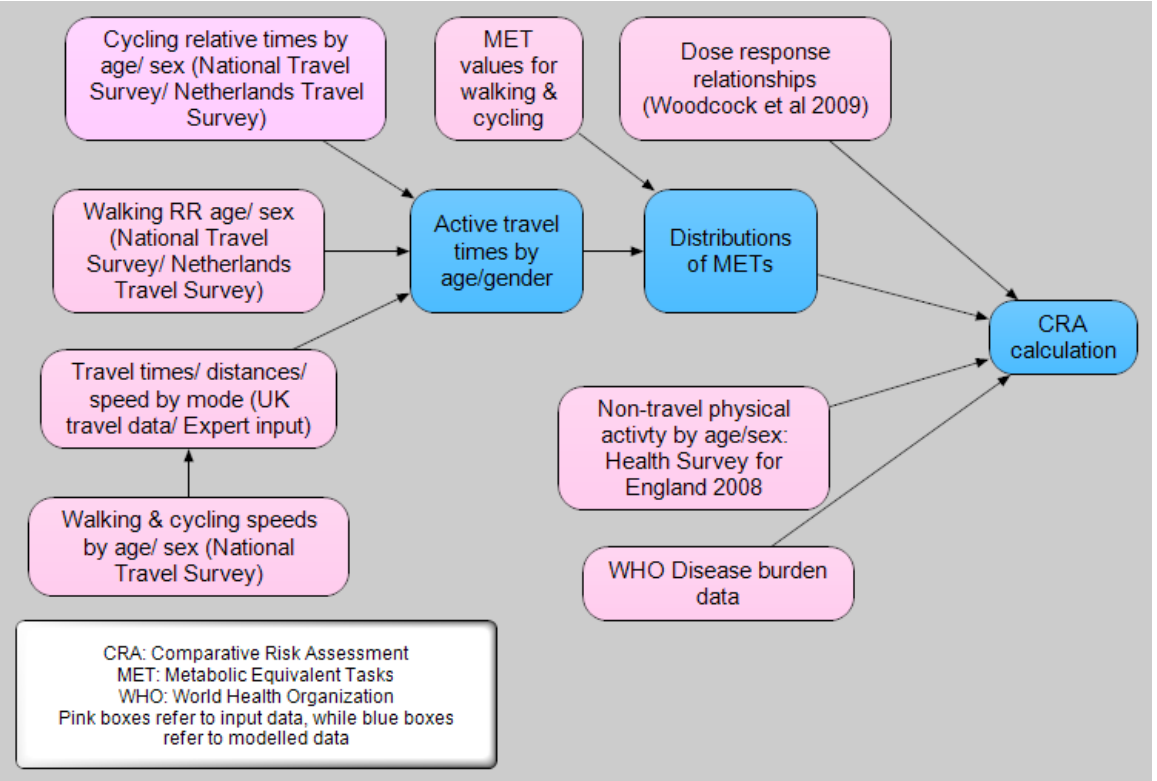
- Set aside estimation sample
- Compare to intersection counts
- Transferability: Evaluate the performance of models in many different communities
- Compare the performance of several different types of models in the same study area
- Have practitioners and advocates carefully review predicted volumes against their local knowledge



Link to Health Outcomes

- Health impact analysis
- Total time spent walking + speeds
- Physical activity budgets
- Crash risk exposure
- Pollutant exposure
- Feedback into life expectancy



Woodcock J, Givoni M, Morgan AS. Health Impact Modelling of Active Travel Visions for England and Wales Using an Integrated Transport and Health Impact Modelling Tool (ITHIM). Barengo NC, ed. PLoS ONE. 2013;8(1):e51462

Conclusions

- Tools for pedestrian (& bicycle) demand have matured
- Still lag behind motorized modes in sophistication and application
- Expanding list of policy issues
- More information & data
- Plenty of research questions!

Questions?

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Project info & reports:

http://trec.pdx.edu/research/project/510
http://trec.pdx.edu/research/project/677

Singleton, P. A., Schneider, R. J., Muhs, C. D., & Clifton, K. J. (2014). "The Pedestrian Index of the Environment (PIE): Representing the Walking Environment in Planning Applications," *Proceedings of the 93rd Annual Meeting of the Transportation Research Board*, 2014.

Clifton, K. J., Singleton, P. A., Muhs, C. D., & Schneider, R. J. 2016. "Representing pedestrian activity in travel demand models: Framework and applications", *Journal of Transport Geography*, Vol. 52:111-122. http://dx.doi.org/10.1016/j.jtrangeo.2016.03.009.

Clifton, K. J., Singleton, P. A., Muhs, C. D., & Schneider, R. J. 2016. "Development of destination choice models for pedestrian travel", *Transportation Research Part A*, 94: 255-265