Representing Walking in Trip-Based Travel Demand Forecasting Models

~~ A Proposed Framework ~~

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ITS
OTREC OREGON TRANSPORTATION RESEARCH AND EDUCATION CONSORTIUM
Metro

Outline

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- Introduction and Background
- Current and Proposed Method
- Trip Generation
  - Pedestrian Analysis Zones (PAZ)
- Walk Mode Split
  - Pedestrian Index of the Environment (PIE)
  - Model Estimation
- Considerations and Future Work

Overview

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- **Partner with Metro on research grant**
  - ***"Improving the representation of the pedestrian environment in travel demand models"***
- **Motivating uses**
  - **Evaluate policy-sensitive mode shifts away from automobile travel**
  - **Calculate greenhouse gas emissions**
    - **Oregon SB 1059, HB 2001**
  - **Utilize archived walking and environmental data for pedestrian planning**

State of the Practice

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- Most large MPO models (62%) forecast walking and/or "non-motorized" travel
- Recent trends
  - Activity-based surveys and models
  - Pedestrian environment data
    - e.g., sidewalk networks
  - Smaller or sub-TAZs for some aspects
  - Walk & bike network assignment/route choice

Literature Review

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- What environmental factors appear to influence the choice to walk?
  - Residential and employment density
  - Land use mix/diversity
  - (Pedestrian) network connectivity
  - Accessibility to transit
- Challenge: many associated environmental factors are spatially correlated

Current Method (Metro)

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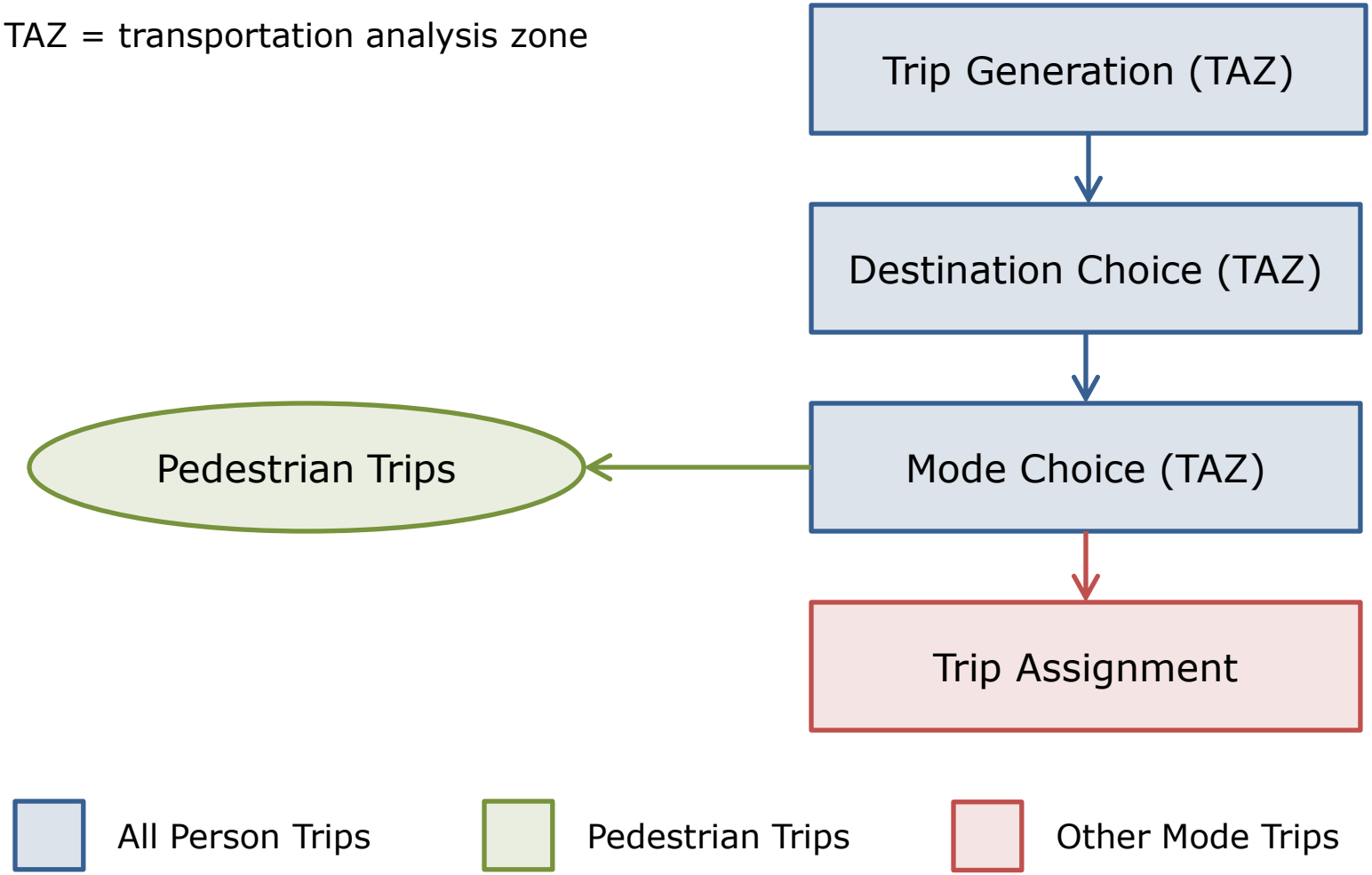
TAZ = transportation analysis zone



Proposed Method

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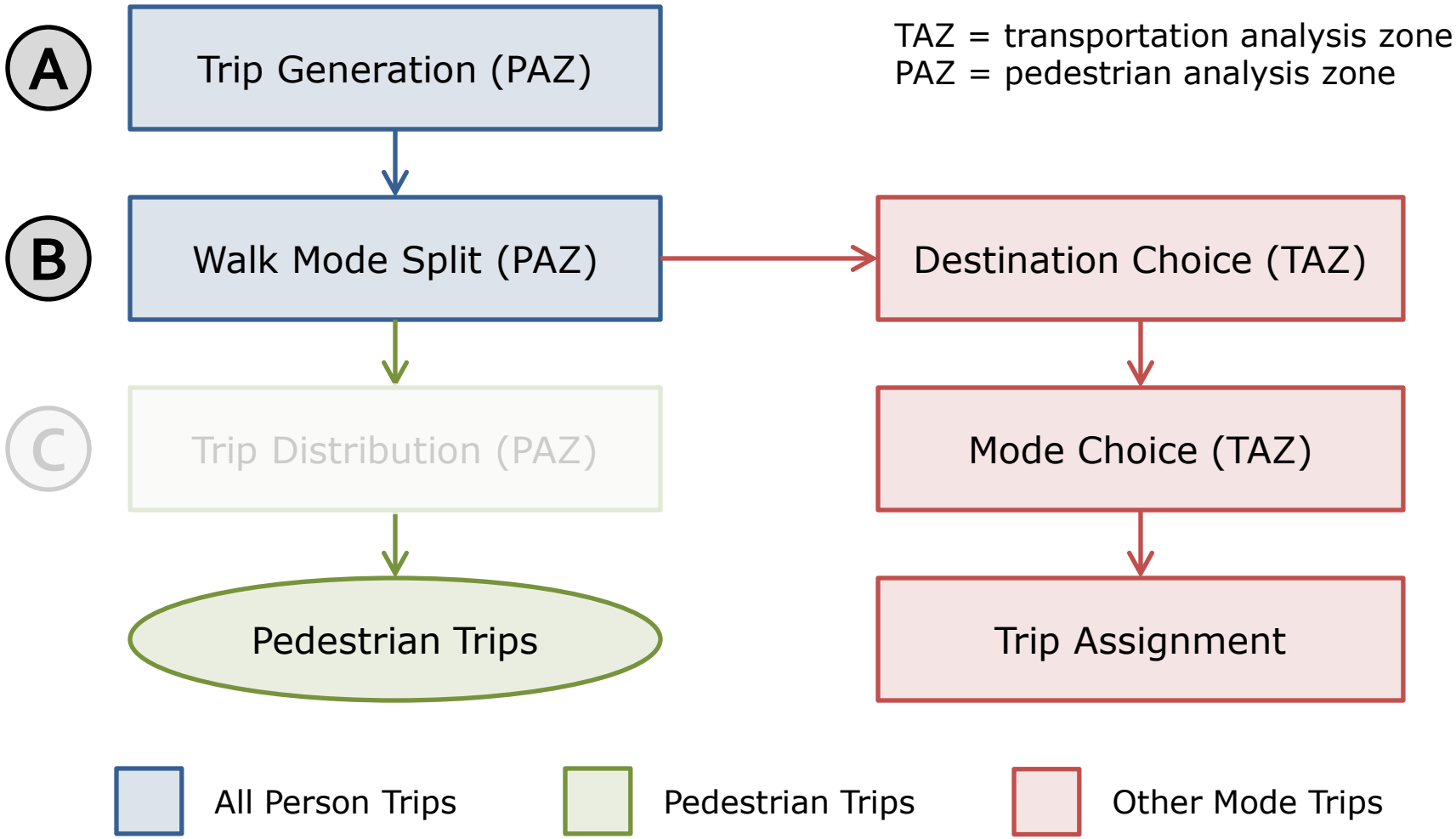

Ⓐ Trip Generation

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- Use Metro's existing Trip Generation processes for the same 8 trip purposes
  - Trip production rates by HH size and workers
- Apply at a scale that is more sensitive to pedestrian environments
  - "Pedestrian Analysis Zones" (PAZs)

What are PAZs?

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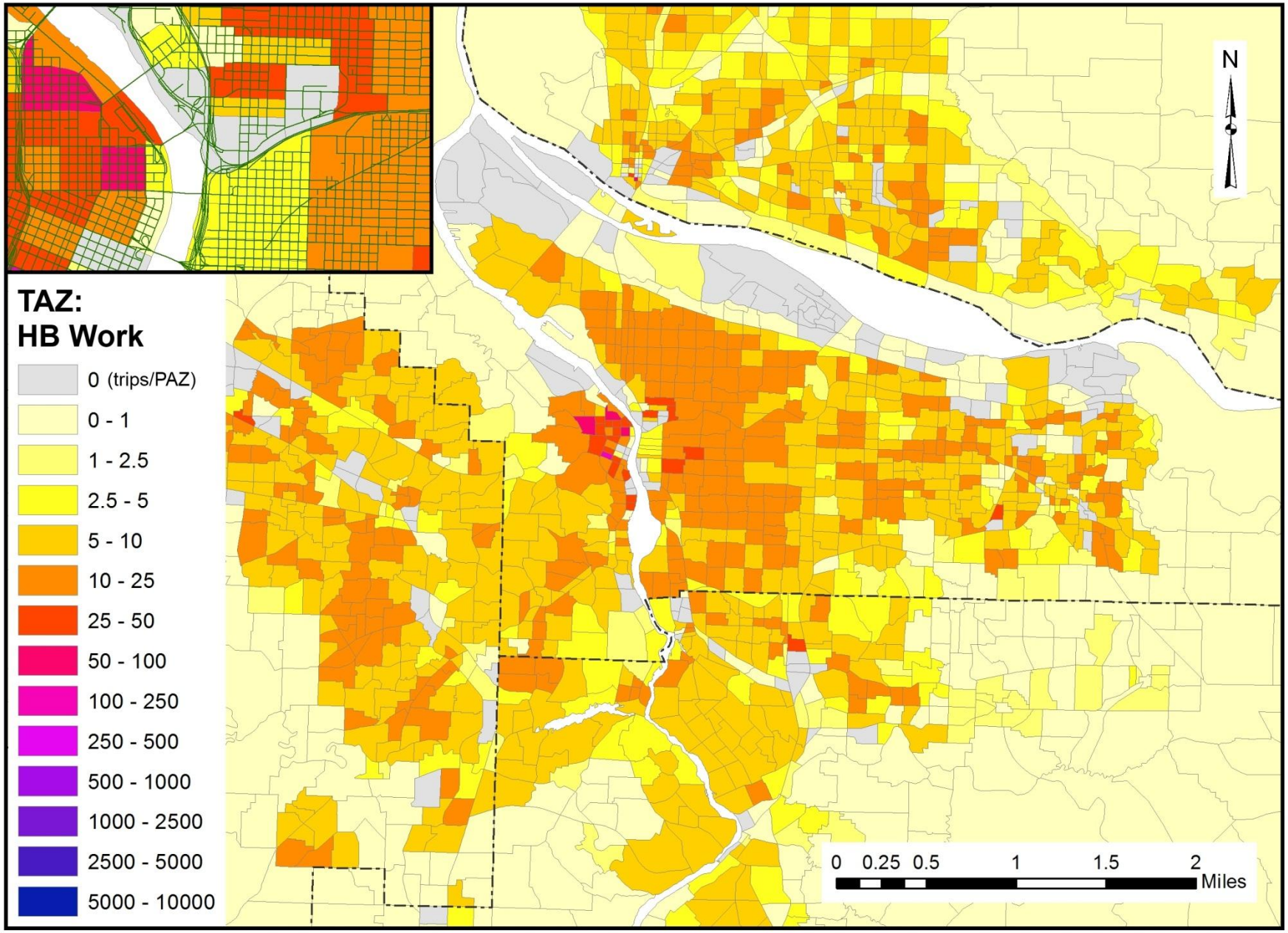
- From Metro's Context Tool
  - https://gis.oregonmetro.gov/cistool/
- 264 feet by 264 feet raster grid cells
  - 1/20th mile ≈ 1 minute walk (3 mph)
- 1.5 million in four-county region
- Scale is more sensitive to walking environments and variations in land use

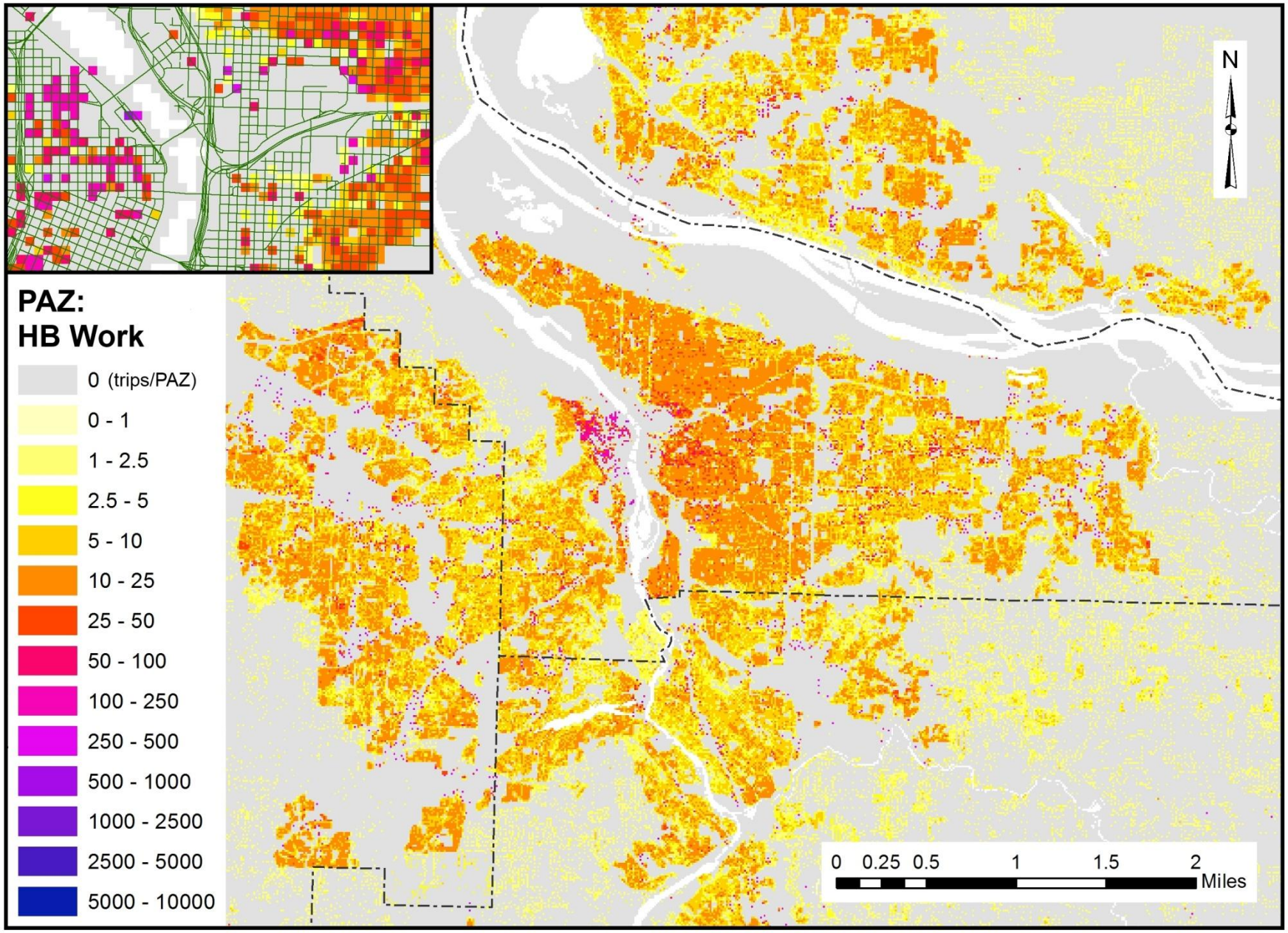
Trip Generation Outputs

TAZ Home-Based Work Productions



Trip Generation Outputs

PAZ Home-Based Work Productions



Ⓑ Walk Mode Split

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- Pedestrian vs. non-pedestrian trip ends
- Binary logit (logistic) regression

P(walk) = *f*(household characteristics, pedestrian environment)

- Estimate using trips, apply to PAZs

Travel(er) Data

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- Oregon Household Activity Survey (OHAS)
- Portland region dataset (2011)
  - 6,100 households; 13,400 people
  - 56,000 trips (linked/full)
  - 4,500 walking (only) trips
- Personal characteristics limited to household variables in Metro model:
  - Size, income, age, workers, children, autos

Pedestrian Environment

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- "Pedestrian Index of the Environment" (PIE)
  - Scores range 20 to 100
  - Weighted sum of 6 Context Tool dimensions, each scored 1 to 5:

Dimension	*Weight*
People density	4.615
Transit access	3.529
ULI[1] density	3.120

Dimension	*Weight*
Block size	3.086
Sidewalk density	2.842
Bicycle access	2.808

[1] ULI = Urban Living Infrastructure: shopping and service destinations used in daily life.
See http://johnson-gardner.com/files/Urban_Amenities_Final5.pdf and http://otrec.us/project/407/.

What is PIE?

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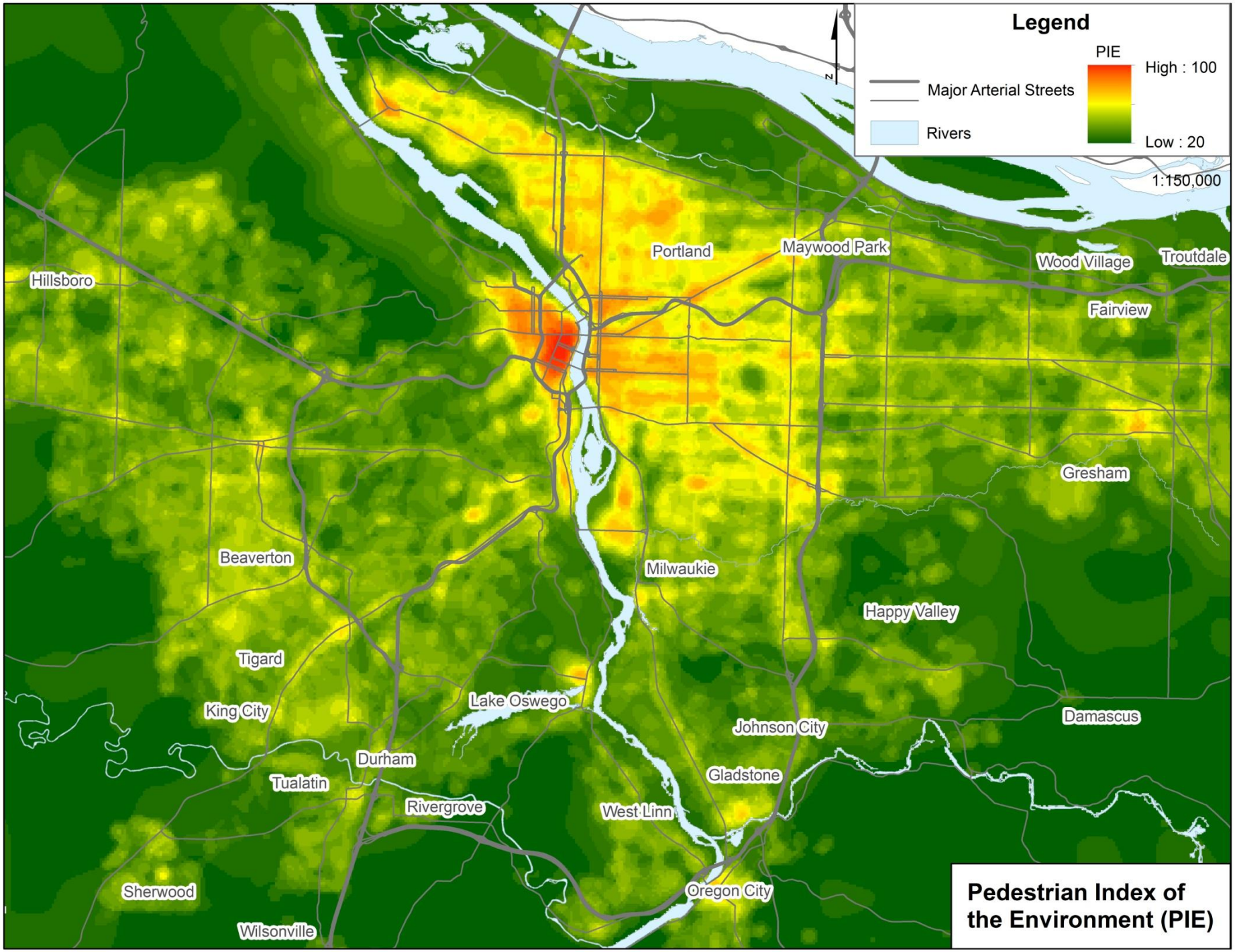
- "Reason for travel" (people density) weighted highest of all dimensions
- Correlated with walking (ρ = 0.26)
- Highly correlated with other "direct" measures of the built environment:
  - Household density (ρ = 0.76)
  - Employment density (ρ = 0.63)
  - Sidewalk density (ρ = 0.83)


Legend
PIE
High : 100
Low : 20
Major Arterial Streets
Rivers
1:150,000
N
Portland
Maywood Park
Wood Village
Troutdale
Hillsboro
Fairview
Gresham
Beaverton
Milwaukie
Happy Valley
Tigard
King City
Lake Oswego
Johnson City
Damascus
Durham
Tualatin
Gladstone
Rivergrove
West Linn
Sherwood
Oregon City
Wilsonville
Pedestrian Index of the Environment (PIE)

Visualizing PIE

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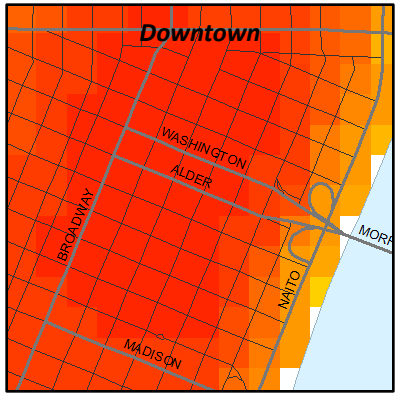
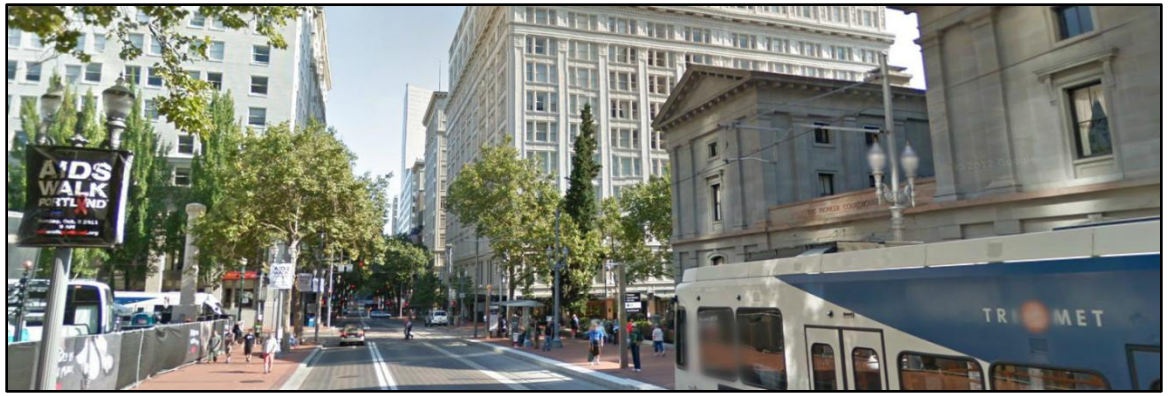
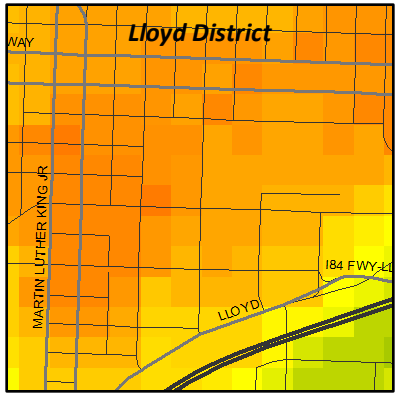
100 – Downtown core (Portland Downtown)





80 – Major neighborhood centers (Hollywood, Lloyd District)



Visualizing PIE

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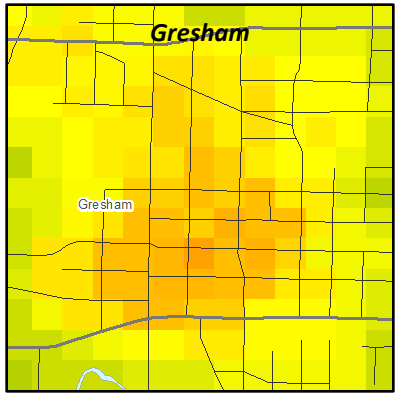
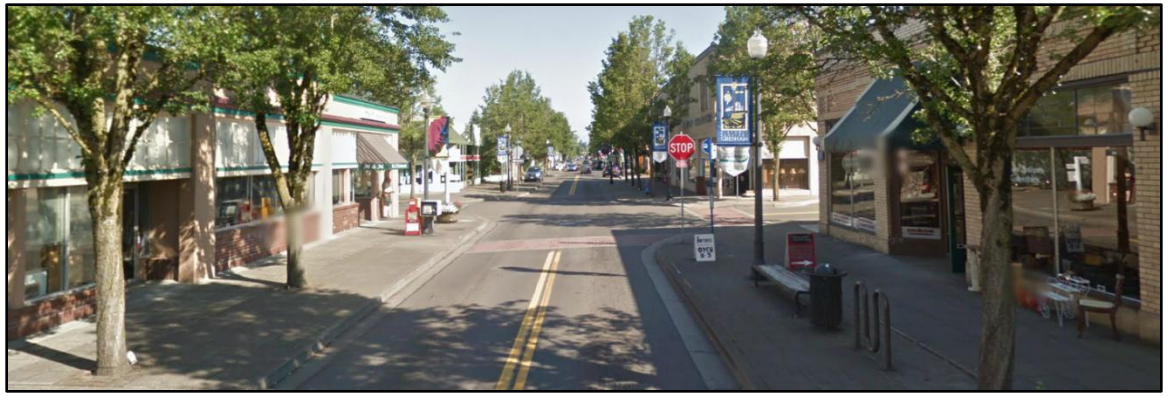
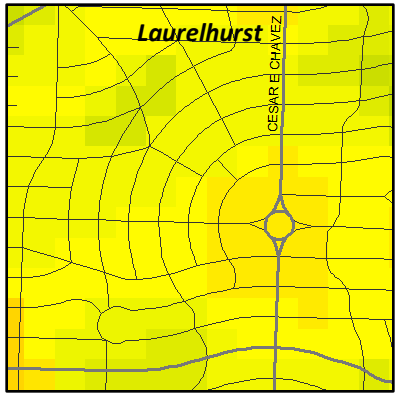
70 – Suburban downtowns (Beaverton, Gresham, Hillsboro)



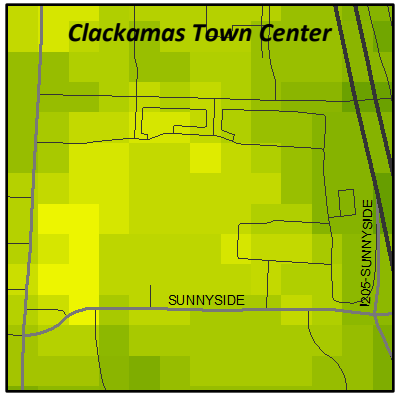


60 – Residential inner-city neighborhoods (Brooklyn, Laurelhurst)

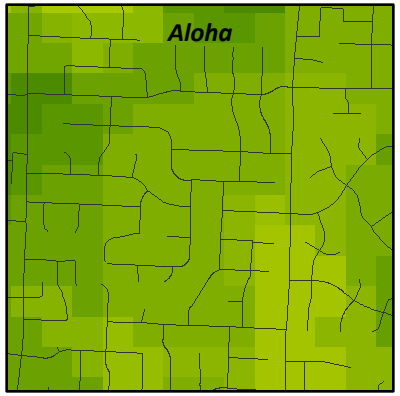


Visualizing PIE

50 – Suburban shopping malls (Clackamas Town Center)



40 – Suburban neighborhoods/subdivisions (Aloha, Metzger)



Visualizing PIE

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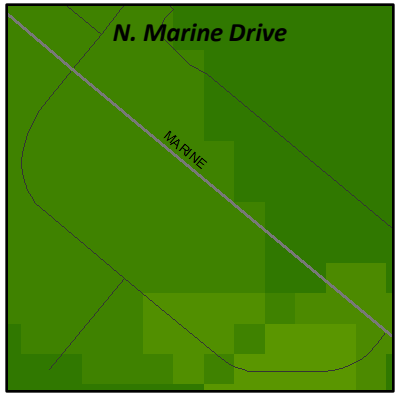
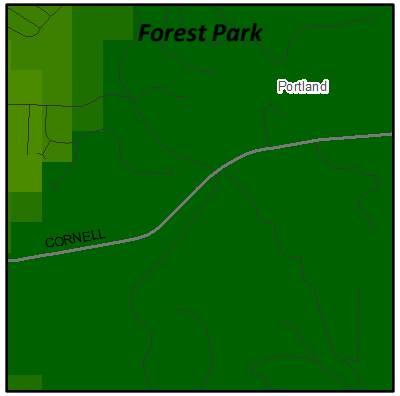
30 – Isolated business and light industry (Marine Drive)



20 – Rural, undeveloped, forested (Forest Park, Damascus)



Model Estimation

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- Binary logit (logistic) regression
- OHAS 90% estimation sample (N = 50,271)
- Segmented by trip purpose:
  - Home-based work (HBW)
  - Home-based other (HBO)
  - Non-home based (NHB)

HBW Model

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Variable	Sign
Age of Household Head, 0 - 24	+
Age of Household Head, 55 - 64	+
Household Size, 3	+
Number of Children, 2	+
Number of Children, 3+	+
Household Income, $25K - $35K	-

Variable	Sign
Number of Vehicles, 0	+
Number of Vehicles, 2	-
Number of Vehicles, 3+	-
Pedestrian Index of Environment	+
Constant	-

275 Walk Trip Ends / 8,917 = 3.08%

Pseudo R^2 = 0.151

+1 point on PIE scale → +3.6% in walk likelihood

HBO Model

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Variable	Sign
Age of Household Head, 55 - 64	-
Household Size, 2	+
Number of Workers, 1	+
Number of Workers, 2	+
Number of Children, 1	+
Number of Children, 2	+
Number of Children, 3+	+
Number of Vehicles, 0	+

Variable	Sign
Number of Vehicles, 2	-
Number of Vehicles, 3+	-
Freeway Miles w/in Eighth Mile	-
Pedestrian Index of Environment	+
Home-Based Shopping Trip	-
Home-Based Recreation Trip	+
Home-Based School Trip	+
Constant	-

2,490 Walk Trip Ends / 26,450 = 9.41%

Pseudo R^2 = 0.137

+1 point on PIE scale → +4.4% in walk likelihood

NHB Model

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Variable	Sign
Age of Household Head, 55 - 64	-
Age of Household Head, 65 - 98	-
Household Income, $75K+	+
Number of Vehicles, 0	+
Number of Vehicles, 2	-

Variable	Sign
Number of Vehicles, 3+	-
Pedestrian Index of Environment	+
Non-Home-Based Non-Work Trip	-
Constant	-

1,329 Walk Trip Ends / 14,904 = 8.92%

Pseudo R^2 = 0.253

+1 point on PIE scale → +5.3% in walk likelihood

Considerations

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- Scalability
  - Trip generation equations
  - Data collection and processing
- Forecasting
  - How to generate household/job forecasts to PAZs or allocate from TAZs?
  - Many options for forecasting PIE
- Operations
  - Computational processing power and time

Possible Future Work

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- PIE refinements and verification:
  - Compare to other walkability measures
  - Assess transferability, alternate constructions
- Further development of method:
  - C Trip distribution / destination choice
  - D Not routing, but "potential pedestrian paths" through PAZs
  - Opportunities to develop a stand-alone pedestrian planning tool
  - Test method in other regions

Questions?

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Project report will be available online:
http://otrec.us/project/510

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