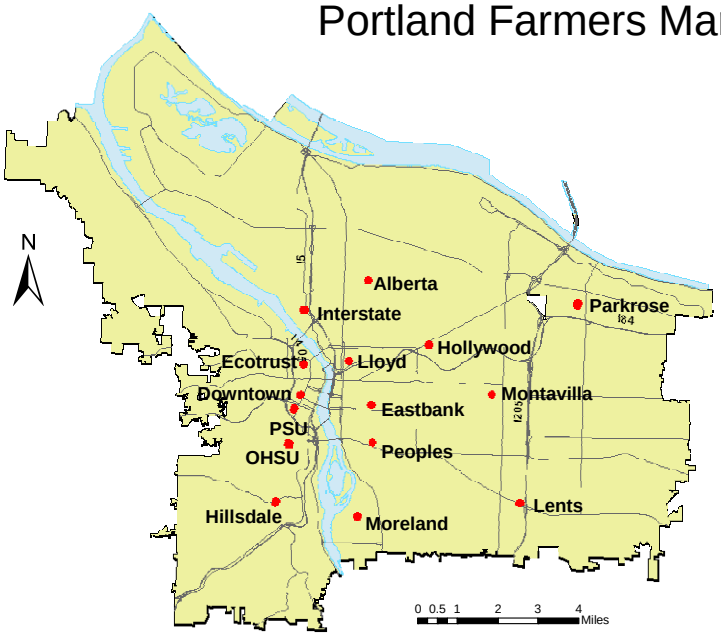
Going for the Greens

Accessibility of Portland Neighborhood Farmers Markets by Sustainable Transportation

Joe Broach, Sarah Horn, and Shawn Sprehe

Portland Farmers Markets



Why Sustainable Transportation?

- Goal of neighborhood farmers' markets is to increase the sustainability of the urban food chain.
- When residents have to drive to the markets, the sustainability benefits of locally grown food will be at least partly offset.
- Equal Access- not all Portlander's have access to a vehicle, they depend on alternative transportation

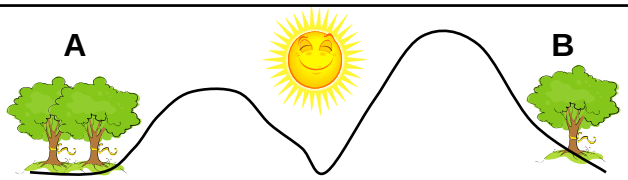
3 GIS Site Accessibility Measures

1) Buffering: straight-line distance

2) Network: vector-based shortest path

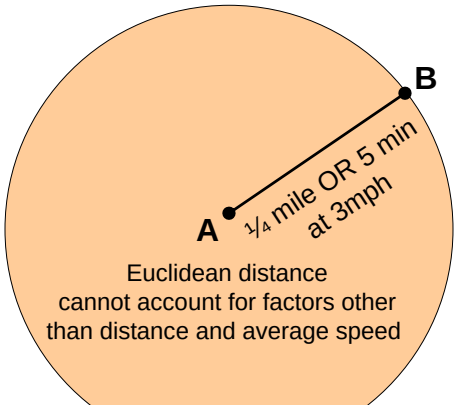
3) Raster: cost-weighted distance over surface

All methods are simplified models of real world travel cost!



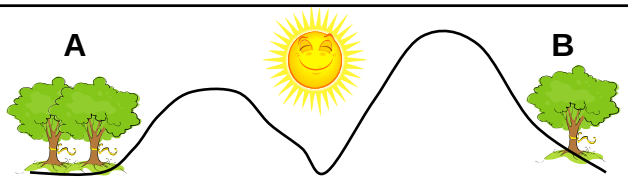
Slope, tree canopy, sidewalks, and traffic are examples of factors that affect the perceived cost of walking.

Buffering



Euclidean distance cannot account for factors other than distance and average speed

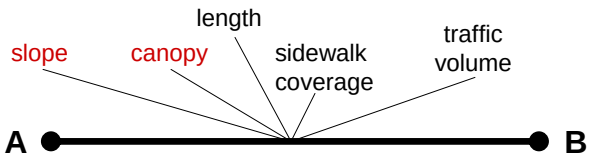
Travel cost A -> B is just the straight-line distance between them!



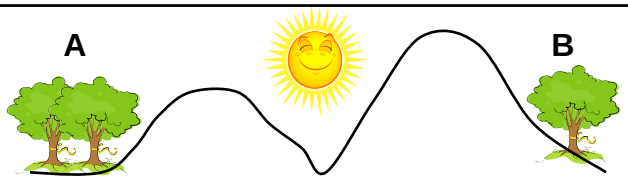
Slope, tree canopy, sidewalks, and traffic are examples of factors that affect the perceived cost of walking.

Network

Attributes of links (edges) affect cost of travel between nodes (vertices)



Travel cost A -> B is the cost of traversing the link!



Slope, tree canopy, sidewalks, and traffic are examples of factors that affect the perceived cost of walking.

Raster

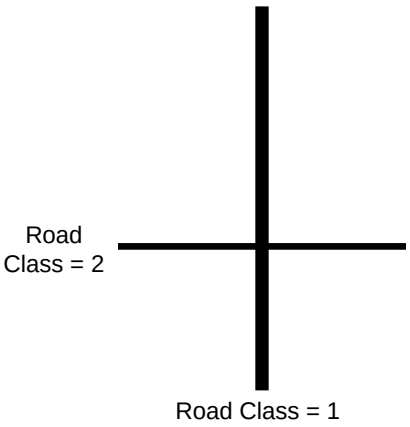
Attributes at the cell level determine separate impedance for each raster cell

0.5 **A** 6.5	1.5 5.5	1.5 4	2.0 2.25	1 0.75	0.5 **B** 0

And each cell has a travel cost from B

Travel cost A -> B is the cost of traversing all of the cells!

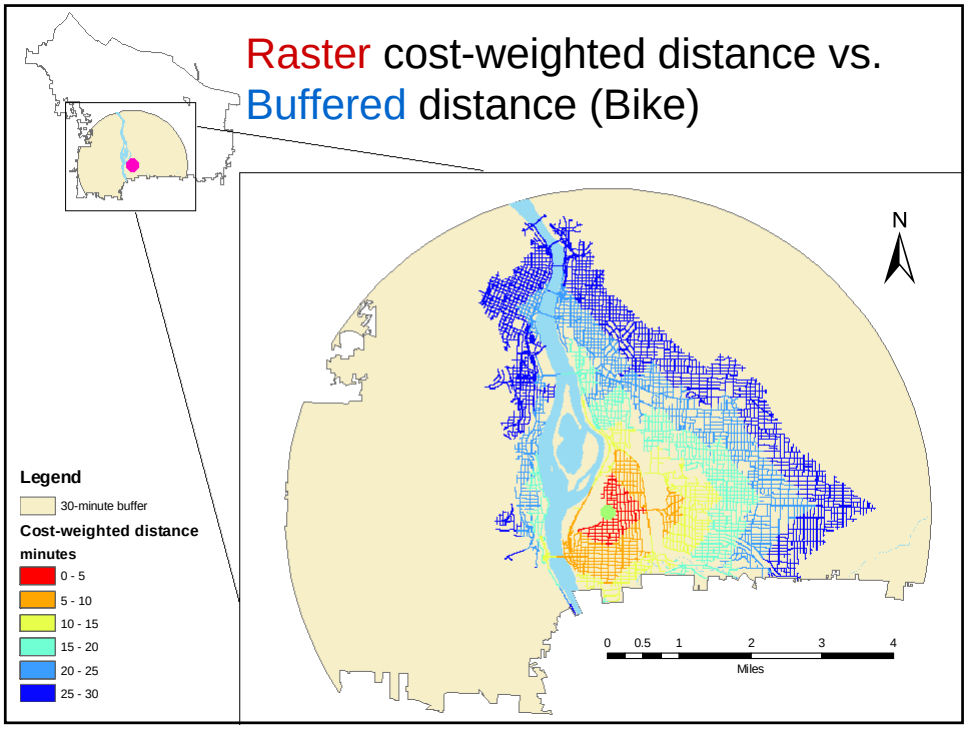
Rasterizing a Network Dataset

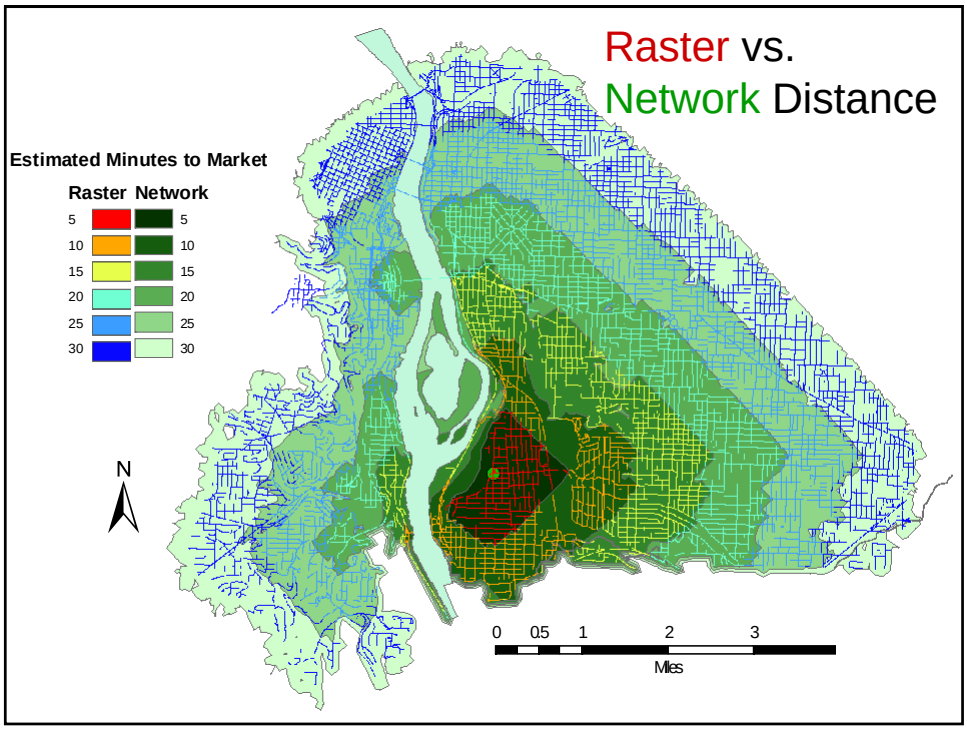


Input

NoData	1	NoData
NoData	1	NoData
2	1 or 2	2
NoData	1	NoData

Output

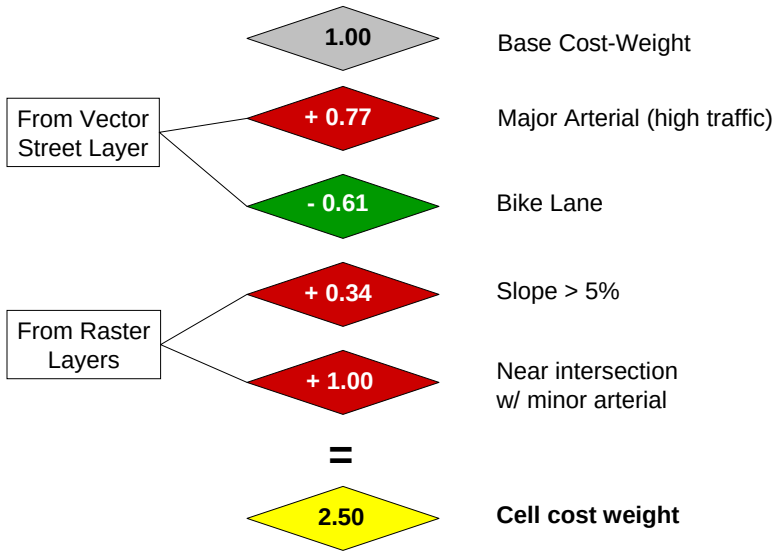

Raster cost-weighted distance vs.
Buffered distance (Bike)
N
Legend
30-minute buffer
Cost-weighted distance
minutes
0 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
0 0.5 1 2 3 4
Miles


Raster vs.
Network Distance
Estimated Minutes to Market
Raster Network
5 5
10 10
15 15
20 20
25 25
30 30
N
0 0.5 1 2 3
Miles

Where cost factors come from

- Choice of factors: existing research subject to data availability
- Weights: existing research, where possible
- Other weights: conservative estimates

Example: Calculating bike cost weight in a cell



What is cost-weighted distance?

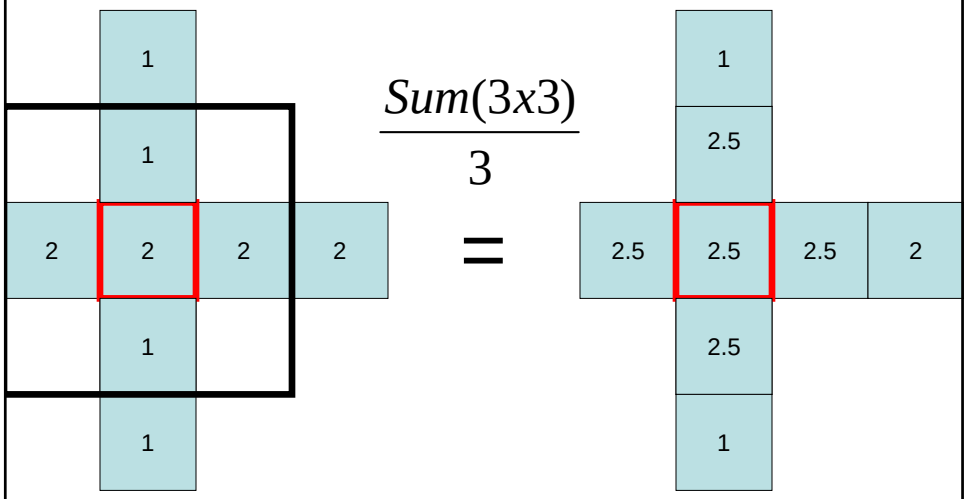
5 minutes bicycling feels like. . .

- 10 on a major arterial, no bike lane
- 6.5 on a non-through residential street
- 5 on a bike boulevard
- 3.3 on a steep path
- 1.6 on a path

5 minutes walking feels like. . .

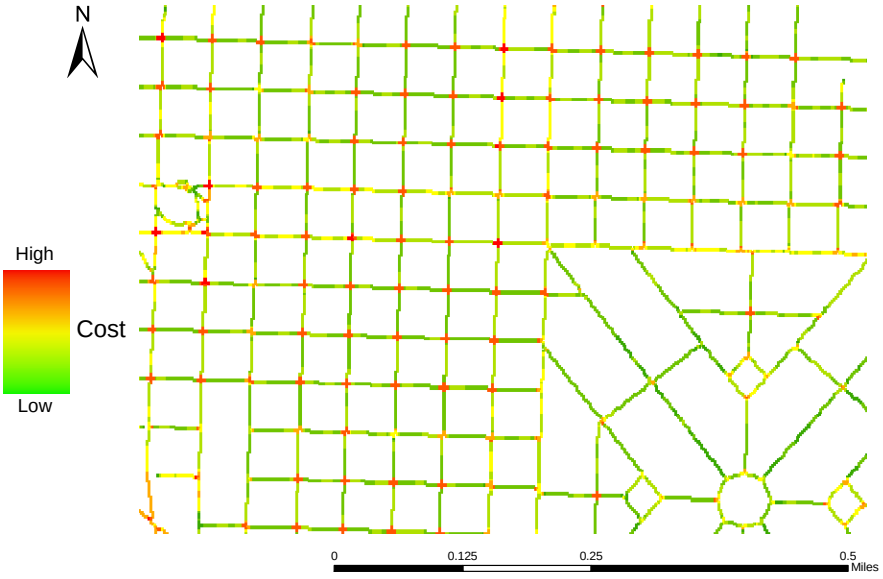
- 7.5 on a major arterial, no sidewalk
- 6.2 on a 5% slope gradient
- 5 on a minor arterial, full sidewalk
- 4.25 under full tree canopy

Calculating intersection penalties with neighborhood statistics



*Actually used 5x5 sums, but this is the idea!

Results:



Bike Model Assumptions

- Off limit biking areas:
  - Freeways and non-multiuse trails
- Additional biking areas besides streets:
  - Regional and Multiuse Paths
- Average cycling speed of 9mph (inclusive of stops)
  - Metro modeling assumption
- Bicycle facilities, street type, slope, and frequency of intersections affects the perceived cost of a bike trip
  - Stinson, M.A. and Bhat, C.R. (2002). An analysis of commuter bicyclist route choice using a stated preference survey. Transportation Research Board Conference 2003.
- Cyclists' stated tradeoff preferences are infinitely divisible and stable across trip types
  - Willingness to trade off 10 minutes on a 20 minute trip implies willingness to trade off 1 minute on a 2 minute trip, etc.
  - Preferences for commute trip and shopping trip similar

Bicycling cost factors

1) Each combination of street type and traffic level were assigned a cost weight derived from Stinson and Bhat (2002).

2) Slopes greater than 5 percent were assessed the "steep hills" premium of 0.34 from Stinson and Bhat (2002)

3) Calculated intersection penalties assessed for reasonableness
   - Range from about 3 – 17.5 seconds

bike_road	description	cost
0	freeway	
11	highway caution area	2.07
12	highway high traffic	2.07
13	highway moderate traffic	2.07
14	highway low traffic	2.07
15	highway w/ bike lane	2.07
16	highway bike boulevard	1
17	highway w/ bike path	0.31
18	highway	2.07
21	major arterial caution area	2.07
22	major arterial high traffic	2.07
23	major arterial moderate traffic	1.55
24	major arterial low traffic	1.15
25	major arterial w/ bike lane	1.46
26	major arterial bike boulevard	1
27	major arterial w/ bike path	0.31
28	major arterial	2.07
31	minor arterial caution area	2.07
32	minor arterial high traffic	2.07
33	minor arterial moderate traffic	1.55
34	minor arterial low traffic	1.15
35	minor arterial w/ bike lane	0.94
36	minor arterial bike boulevard	1
37	minor arterial w/ bike path	0.31
38	minor arterial	1.55
41	residential street caution area	1.92
42	residential street high traffic	1.92
43	residential street moderate traffic	1.4
44	residential street low traffic through	1.15
45	residential street w/ bike lane	0.69
46	residential street bike boulevard	1
47	bike path	0.31
48	residential street	1.3

Walking Assumptions

- Off limit walking areas:
  - Freeways and highways without sidewalks
- Additional walking areas besides sidewalks and streets:
  - Walking trails
  - Regional and local multi-use bike trails
- Average walking speed of 3mph
  - Sastry, R. V. 1999. *A Need for Speed: A New Speedometer for Runners*. Master's Thesis, Massachusetts Institute of Technology.
- Increased canopy improves the walking experience by:
  - Offering shade and weather protection
  - Enhancing aesthetics (appearance of walking areas)
  - Litman, Todd. 2007. *Valuing Transit Service Quality Improvements.* Victoria Transport Policy Institute.
- The amount of sidewalk coverage and road type impacts walking
  - Florida Department of Transportation. 2007. Generalized Annual Average Daily Volumes for Florida's Urbanized Area. www.dot.state.fl.us/planning/systems/sm/los/pdfs/tables-051707.pdf

Walking Cost Factors

- Slope calculation
  - penalty = .048 * (degrees slope)
  - derived from:

Speed, m/min.	Regression Equations (*subject CP*)
45	$\log E_w = 1.630 + 0.0374\ \alpha$
69	$\log E_w = 1.725 + 0.0452\ \alpha$
90	$\log E_w = 1.838 + 0.0506\ \alpha$

E_w = energy expenditure in cal/kg/min. α = gradient in degrees.

  - Bobbert, A. C. 1960. Energy expenditure in level and grade walking. *Journal of Applied Physiology* 15:1015-1021.

- Canopy calculation

Percentage Canopy Coverage	Bonus per Cost Minute
0 – 25	0
25 – 50	.05
50 – 75	.10
75 – 100	.15

Sidewalk & Street Types

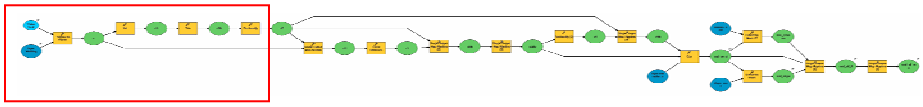
Sidewalk and street type matrix

	Cost			
Sidewalk	**0**	**0.17**	**0.34**	**0.5**
0 - 49%		24,26,34,36,44,45,46,48	23,33,35,38,43	21,22,25,28,31,32,41,42
50 - 84%		24,26,34,36,44,45,46,48,23,33,35,38,43	21,22,25,28,31,32,41,42	
85 - 100%	24,26,34,36,44,45,46,48,23,33,35,38,43	21,22,25,28,31,32,41,42	11,12,13,14,15,16,17,18	

Street type codes

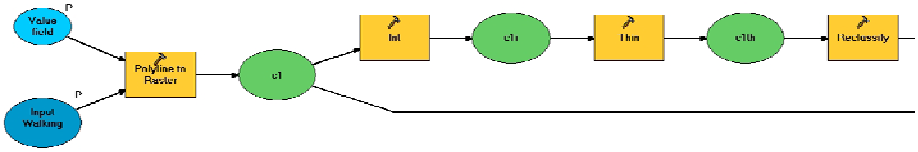
0 freeway
11 highway caution area
12 highway high traffic
13 highway moderate traffic
14 highway low traffic
15 highway w/ bike lane
16 highway bike boulevard
17 highway w/ bike path
18 highway
21 major arterial caution area
22 major arterial high traffic
23 major arterial moderate traffic
24 major arterial low traffic
25 major arterial w/ bike lane
26 major arterial bike boulevard
27 major arterial w/ bike path
28 major arterial
31 minor arterial caution area
32 minor arterial high traffic
33 minor arterial moderate traffic
34 minor arterial low traffic
35 minor arterial w/ bike lane
36 minor arterial bike boulevard
37 minor arterial w/ bike path
38 minor arterial
41 residential street caution area
42 residential street high traffic
43 residential street moderate traffic
44 residential street low traffic through
45 residential street w/ bike lane
46 residential street bike boulevard
47 bike path
48 residential street

Walking & Biking Methodology



Model Overview Part 1

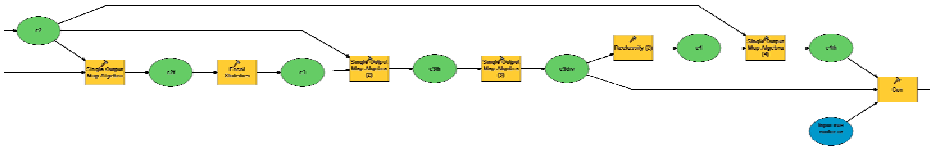
- Transform polyline travel network to raster; raster value taken from sidewalk/bike facility and street-type cost value.
- Thin raster so that travel 'network' is only 1 pixel in width.



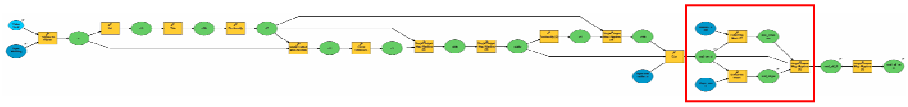
Walking & Biking Methodology

Model Overview Part 2

- Calculate weighting for intersections using 5x5 focal statistics.

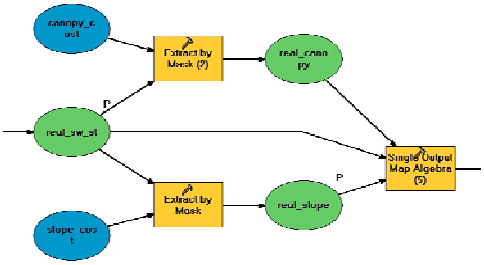


Walking & Biking Methodology

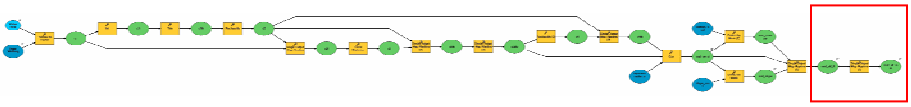


Model Overview Part 3

- Extract canopy (walk) and slope factors from their respective rasters.
- Combine canopy (walk) and slope costs with the existing sidewalk/bike facility and street type cost.

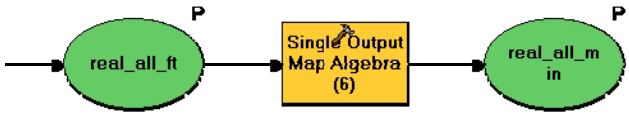


Walking & Biking Methodology



Model Overview Part 4

- Create cost layers, both in feet and minutes.



Public Transit

What Proportion of Portland's Population Can Reach a Farmer's Market by Public Transit?

- What is Public Transit?
  - Bus, light rail, street car, trolley, tram
- How is travel distance usually measured?
- Complexity of Routes = Travel Assumptions

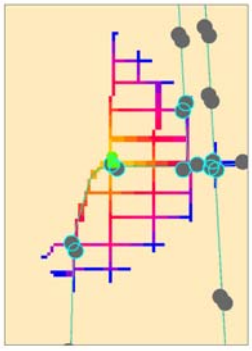
Source: http://trimet.org/

Transit Travel Costs

- Speed of Public Transportation*
  - MAX 16.6 mph, Bus 12.6 mph, other (12.6 mph)
  - MAX cost- .70, Bus & Other cost-1
- Walking time to stop/station
  - Canopy, slope, sidewalk
  - More costly than actual transit time

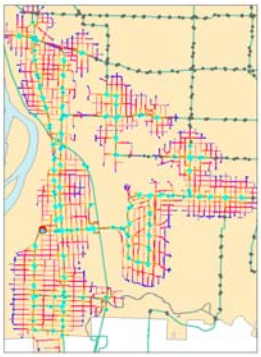
Source: NTD, 2005

Public Transit Methodology



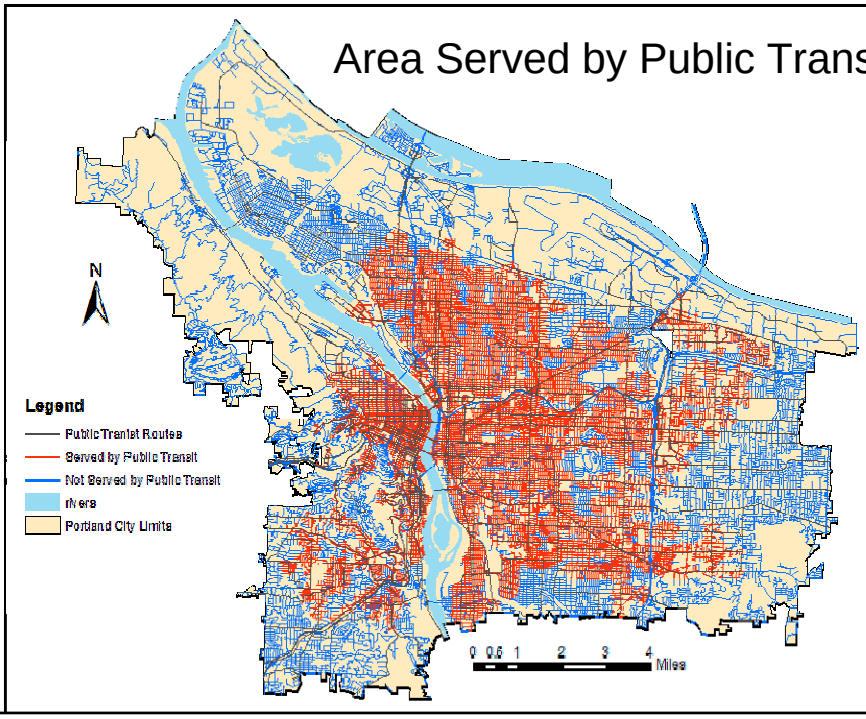
Transit stops
Within 5 minutes
Walking from Market

Transit stops
Within 10 minutes
Transit time from
'market stops'

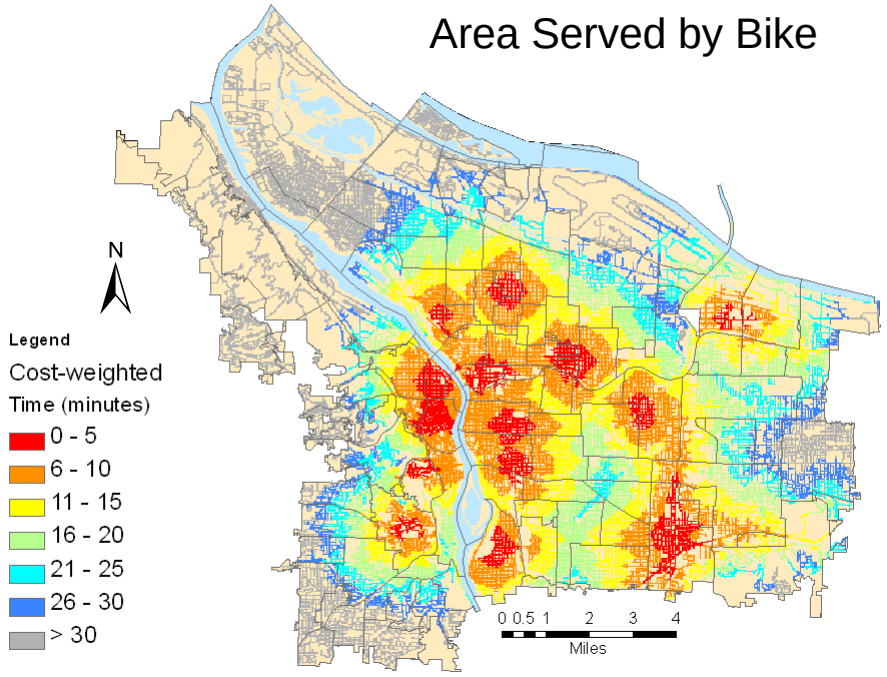


Area Within 5 minutes
Walking times from
'Origin stops'

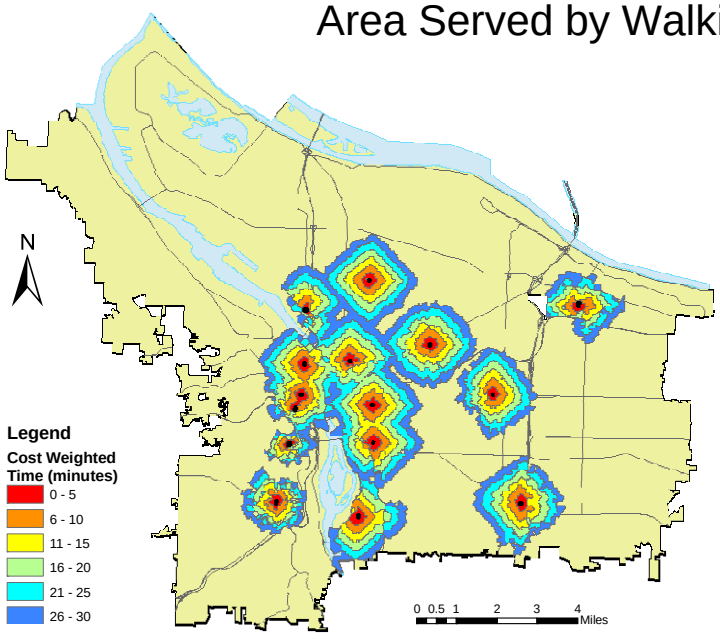
Area Served by Public Transit



Area Served by Bike



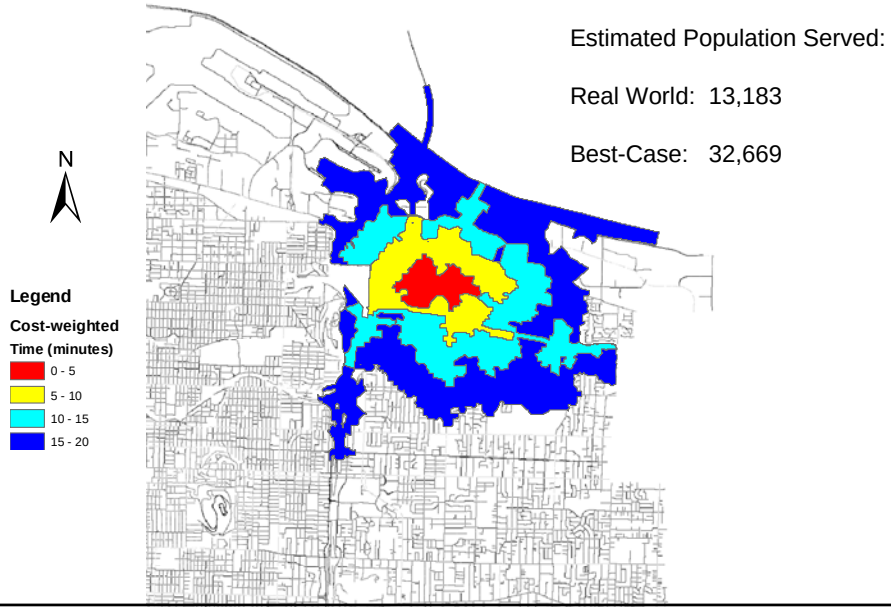
Area Served by Walking



“Best-case” comparisons

- Compare by population served
  - 2000 Census Block population
- Some variables held constant between Actual and Best-Case
  - Slope, demographics, street/trail and market geography
- Some policy variables changed for Best-Case scenario
  - Bike/Ped facilities, intersection design, sidewalk coverage, tree canopy
- Result is a ratio of Actual / Best-Case population served

Real World Parkrose Bicycling Cost

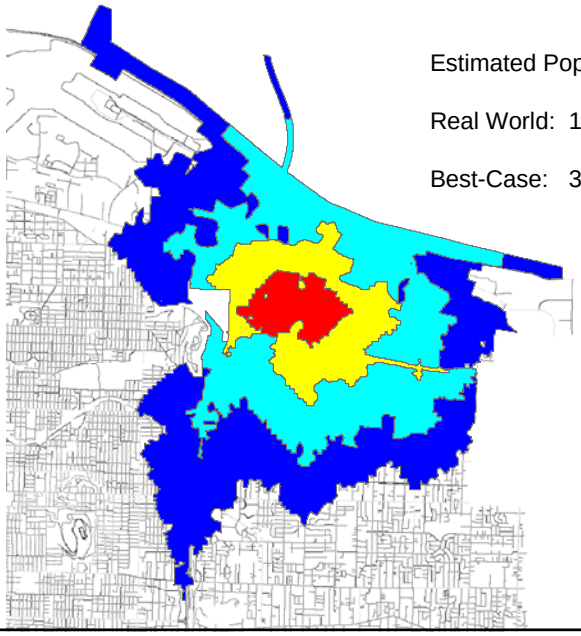


Estimated Population Served:

Real World: 13,183

Best-Case: 32,669

Best-Case Parkrose Bicycling Cost



Estimated Population Served:

Real World: 13,183

Best-Case: 32,669

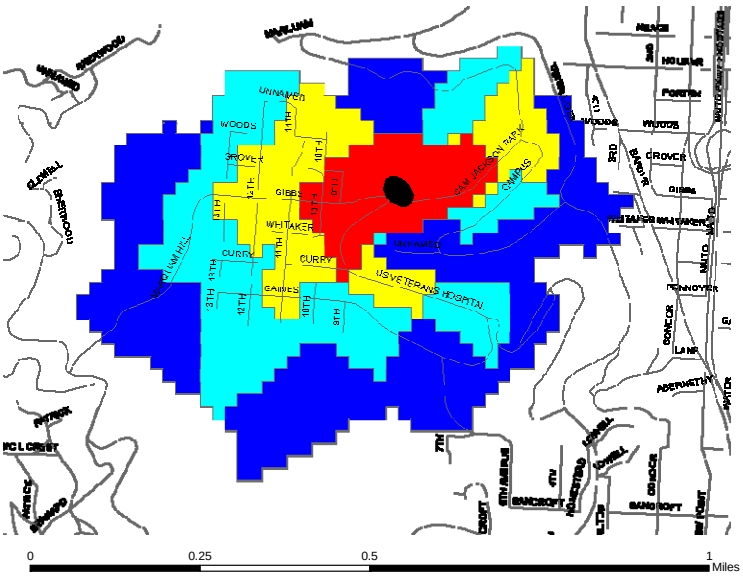
N

Legend

Cost-weighted Time (minutes)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Real World OHSU Walking Cost



N

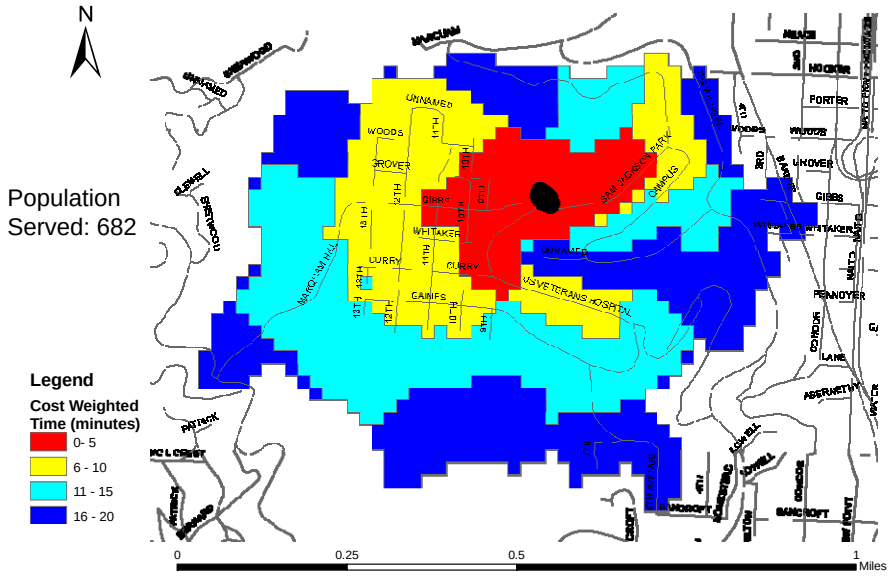
Population Served: 682

Legend

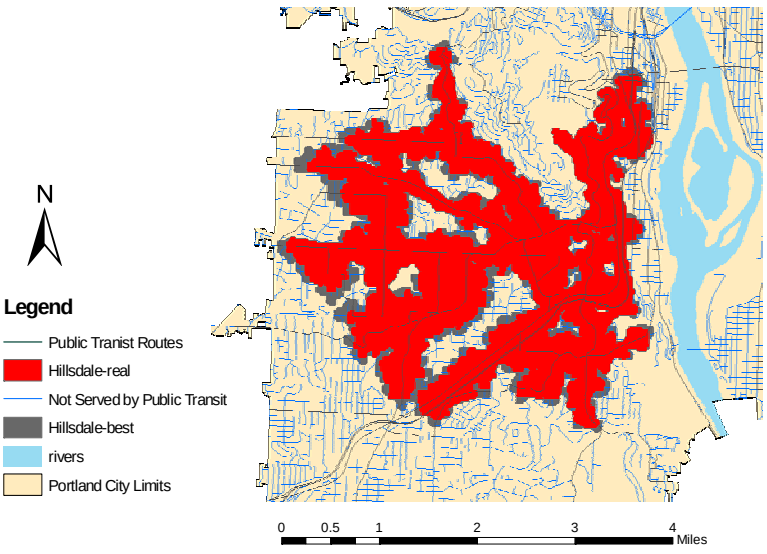
Cost Weighted Time (minutes)

- 0- 5
- 6 - 10
- 11 - 15
- 16 - 20

Best Case OHSU Walking Cost



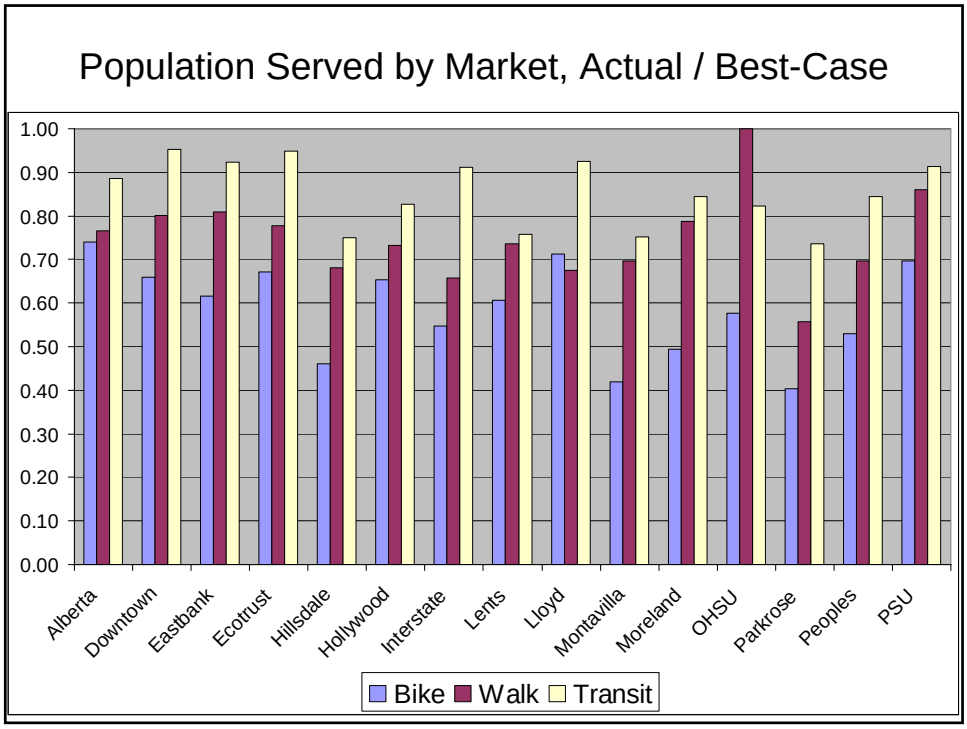
Hillsdale Famers Market Public Transit Access Real vs. Best Case

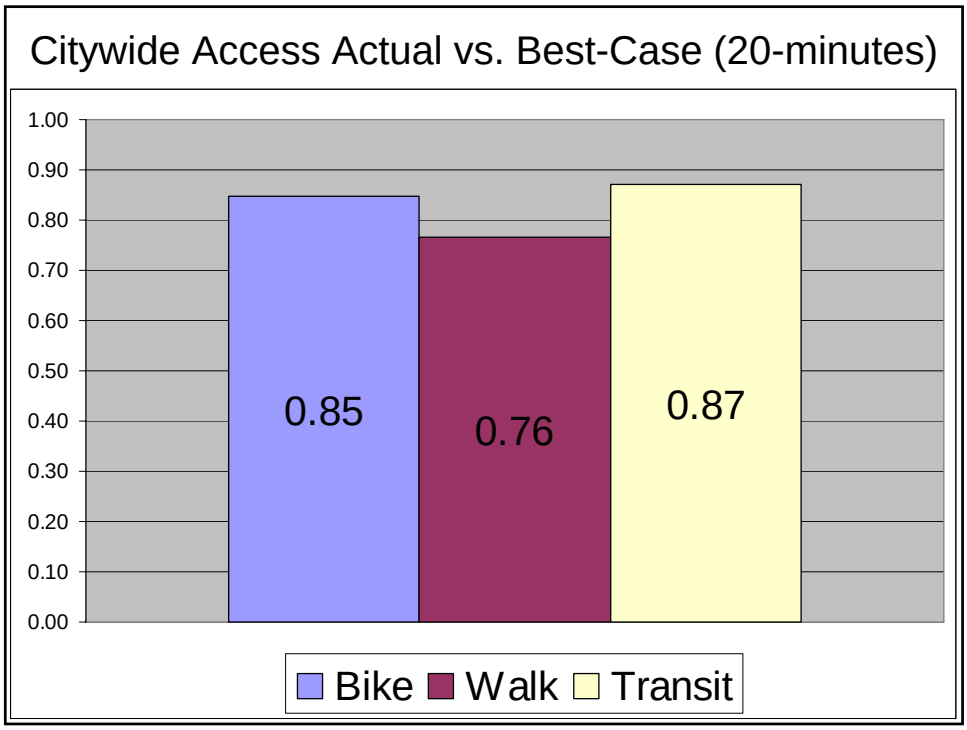


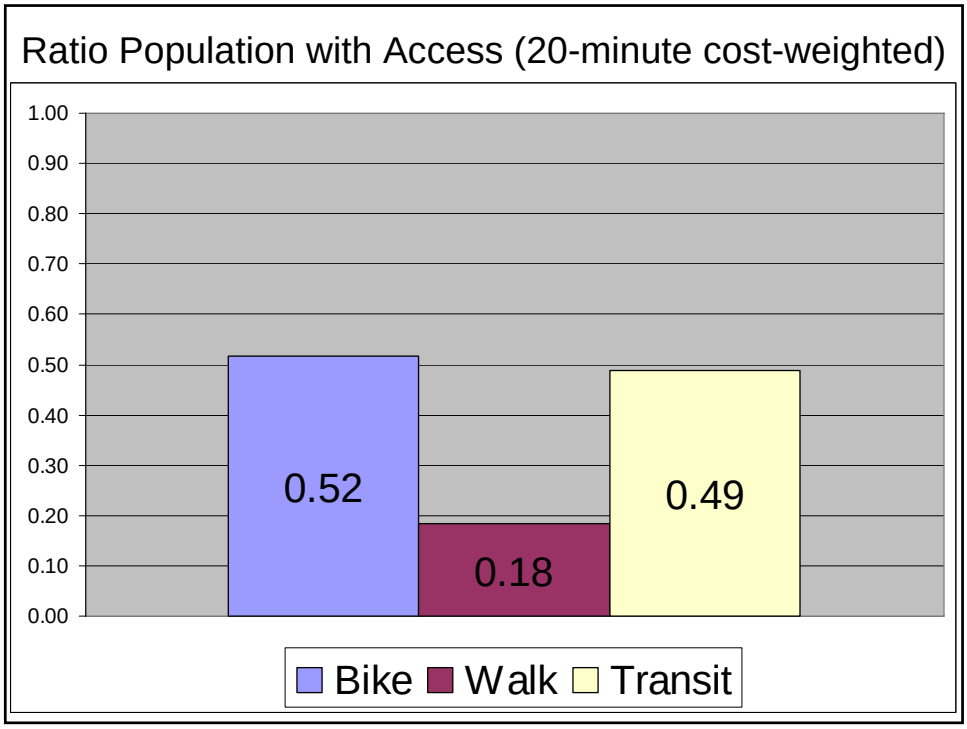
Population Served

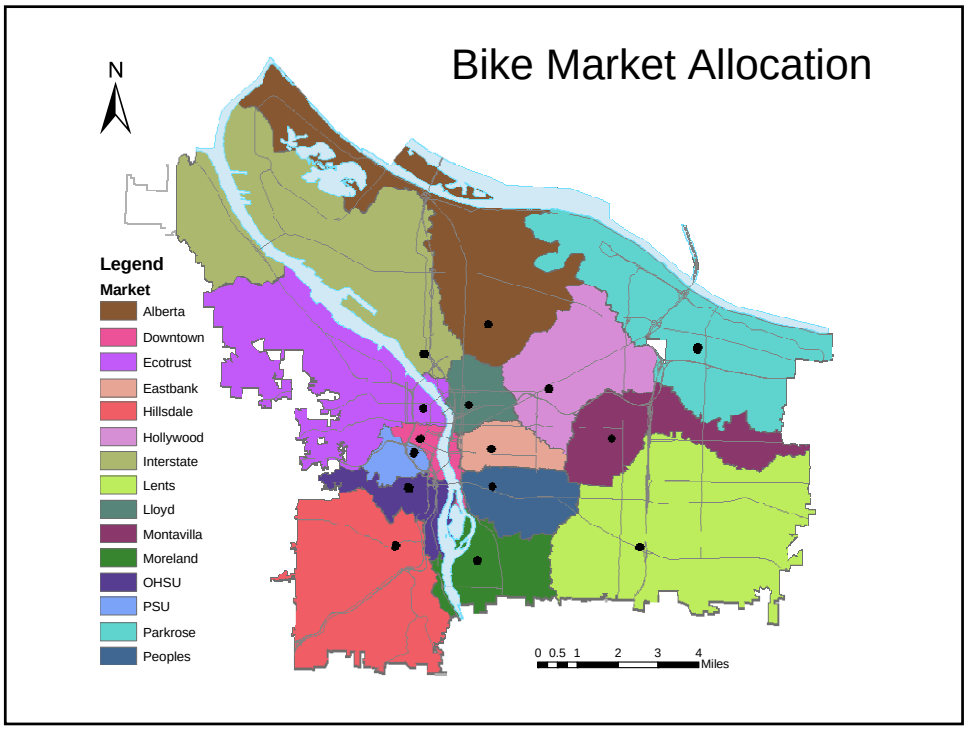
Real Case: 9313

Best Case: 12421


Population Served by Market, Actual / Best-Case
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Alberta
Downtown
Eastbank
Ecotrust
Hillsdale
Hollywood
Interstate
Lents
Lloyd
Montavilla
Moreland
OHSU
Parkrose
Peoples
PSU
Bike
Walk
Transit

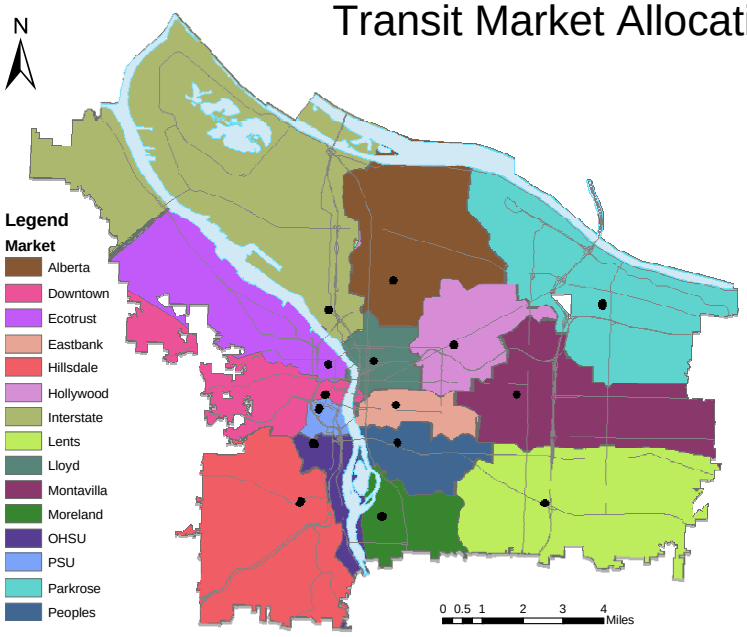

Citywide Access Actual vs. Best-Case (20-minutes)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.85
0.76
0.87
Bike
Walk
Transit


Ratio Population with Access (20-minute cost-weighted)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.52
0.18
0.49
Bike
Walk
Transit


Bike Market Allocation
N
Legend
Market
Alberta
Downtown
Ecotrust
Eastbank
Hillsdale
Hollywood
Interstate
Lents
Lloyd
Montavilla
Moreland
OHSU
PSU
Parkrose
Peoples
0 0.5 1 2 3 4
Miles

Walking Market Allocation

Transit Market Allocation

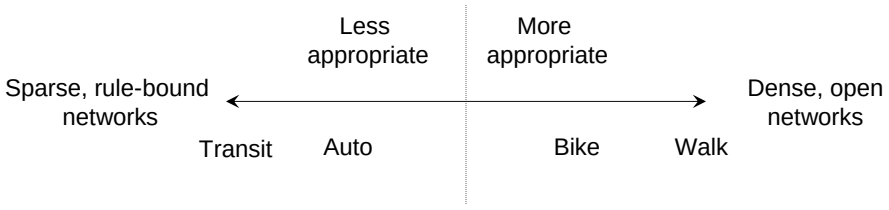


Other Applications

- Measure neighborhood social accessibility
- Analyze environmental justice
- Component of neighborhood sustainability or livability index
- Combine with mode choice survey to test hypotheses about accessibility and mode choice

Discussion

- Raster Network Analysis as applied is a useful GIS method for measuring accessibility for non-motorized modes.



- Neighborhood farmers' markets are generally accessible to bike, walk, and transit modes. Some gaps in access are evident in St. Johns, outer Southwest, and the outer Eastside. Some of these gaps may be partially covered by markets outside the study area.

Walking Literature

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Bicycling Literature

- Stinson, M.A. and Bhat, C.R. (2002). An analysis of commuter bicyclist route choice using a stated preference survey. Transportation Research Board Conference 2003.