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FHWA Guidebook for Measuring Multimodal Network Connectivity

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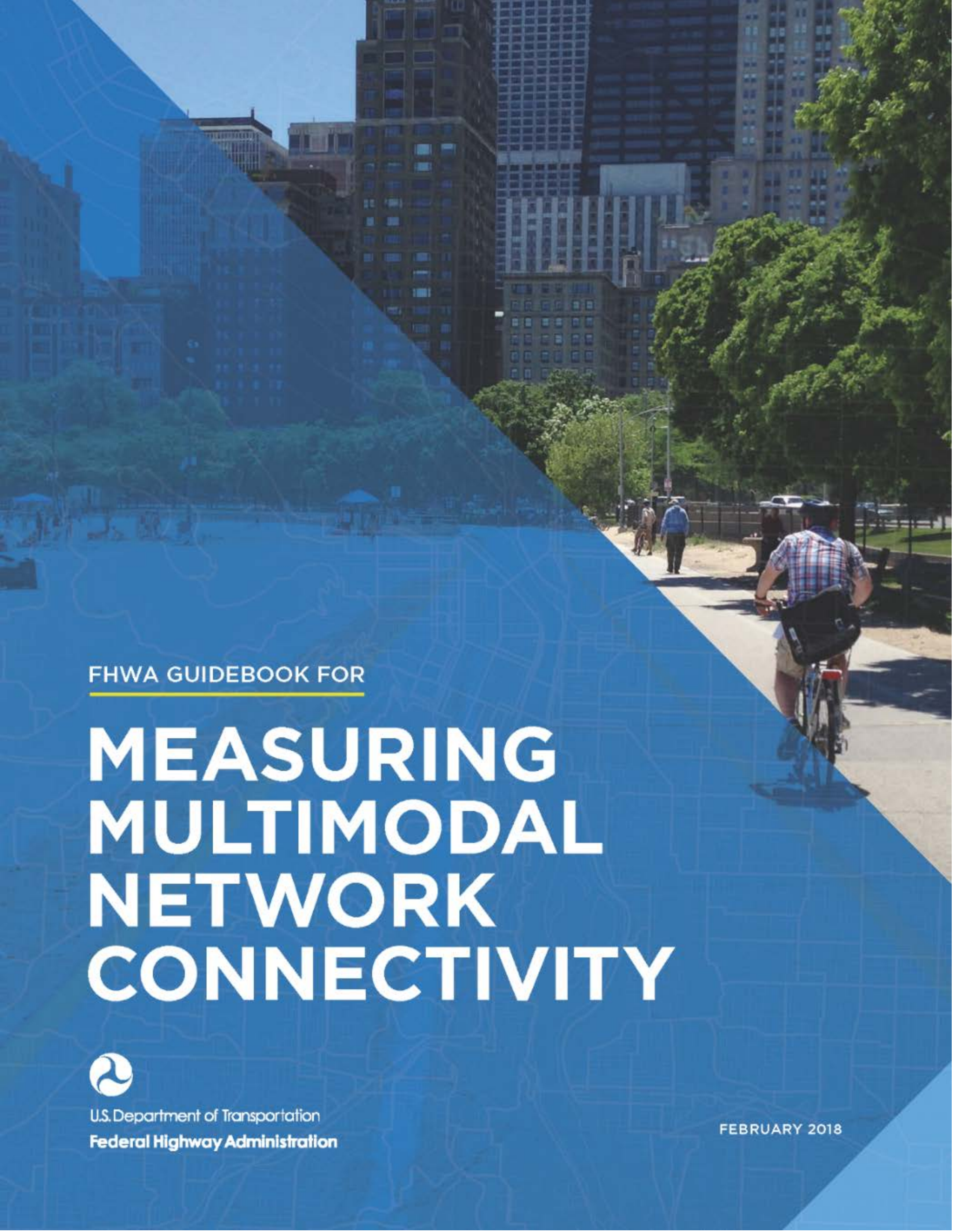

A New Resource for Bicycle & Pedestrian Planning

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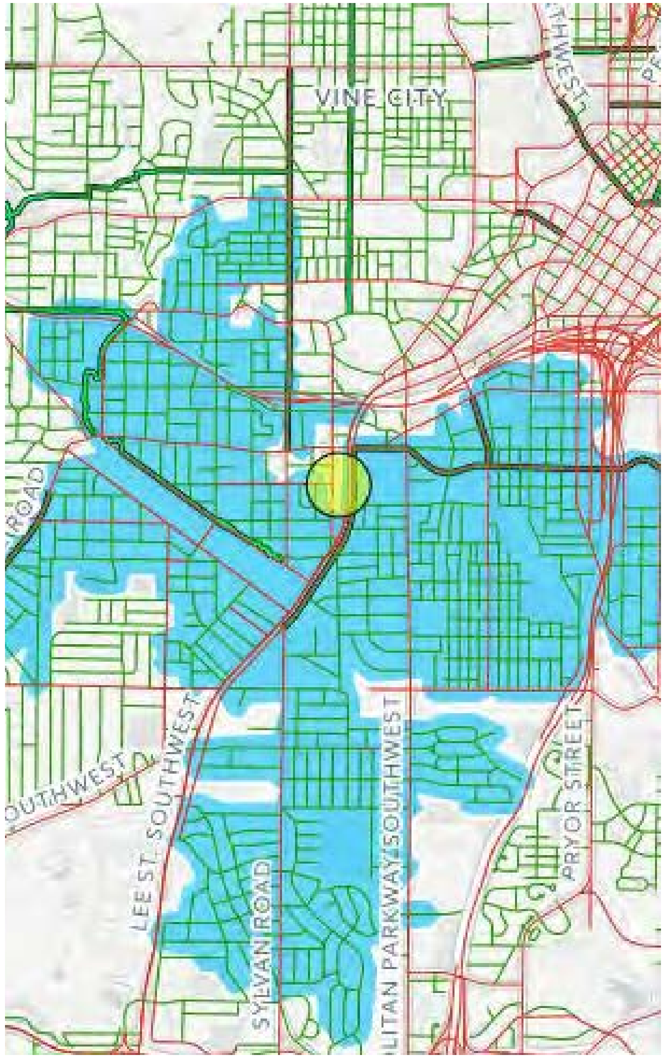
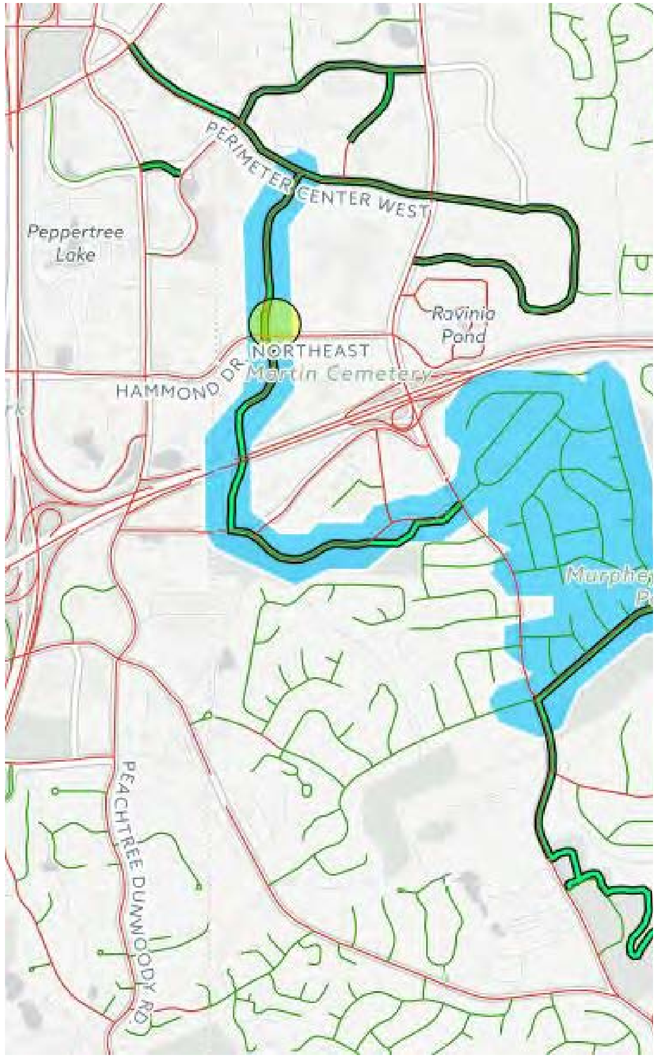
Atlanta Regional Commission

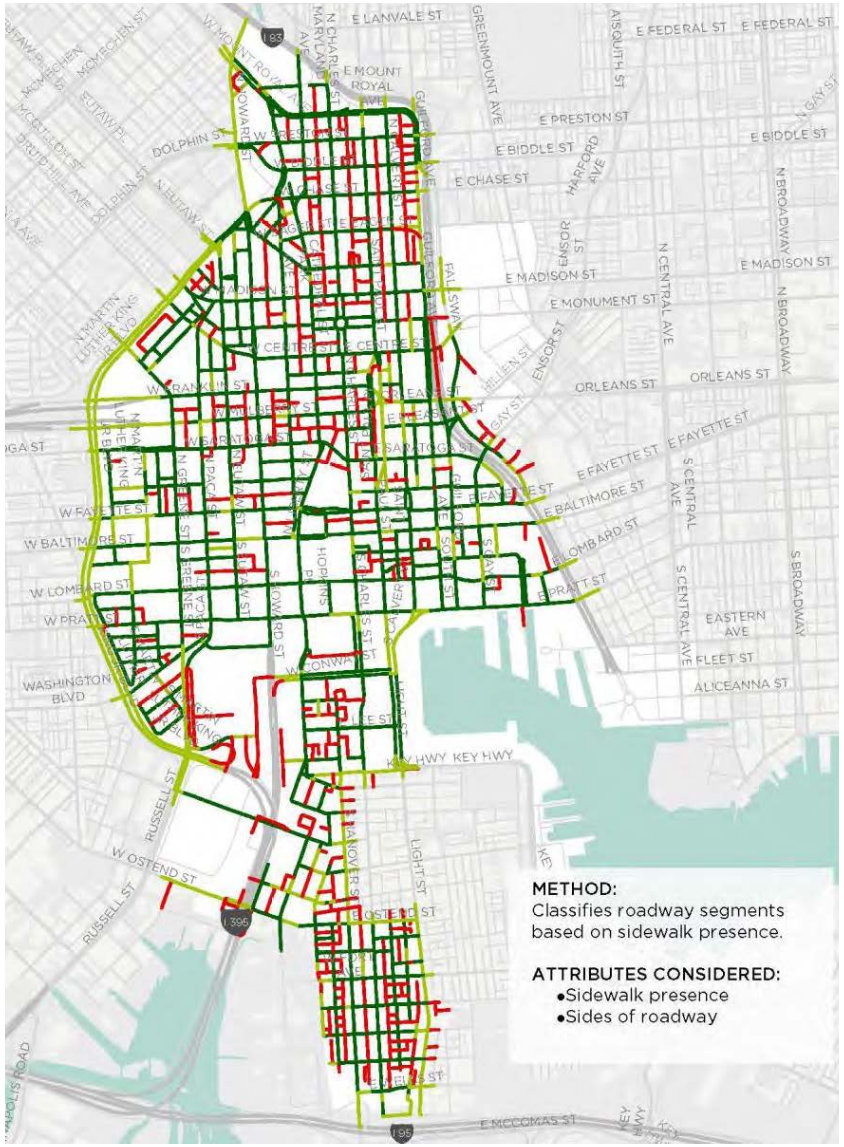
How do we identify bike projects that will better serve local centers—both urban and suburban—in a consistent way?





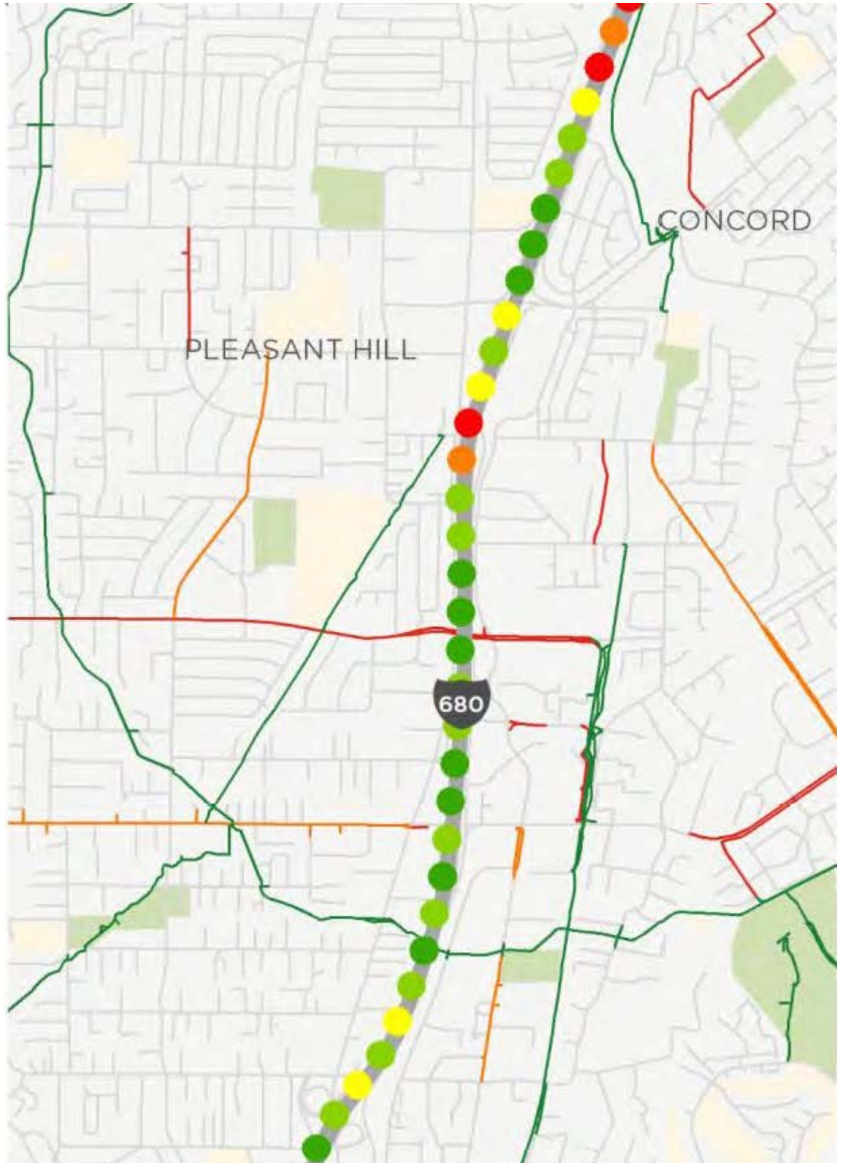
City of Baltimore

We have a sidewalk inventory, but we need a pedestrian measure that's more policy sensitive for planning & benchmarking.



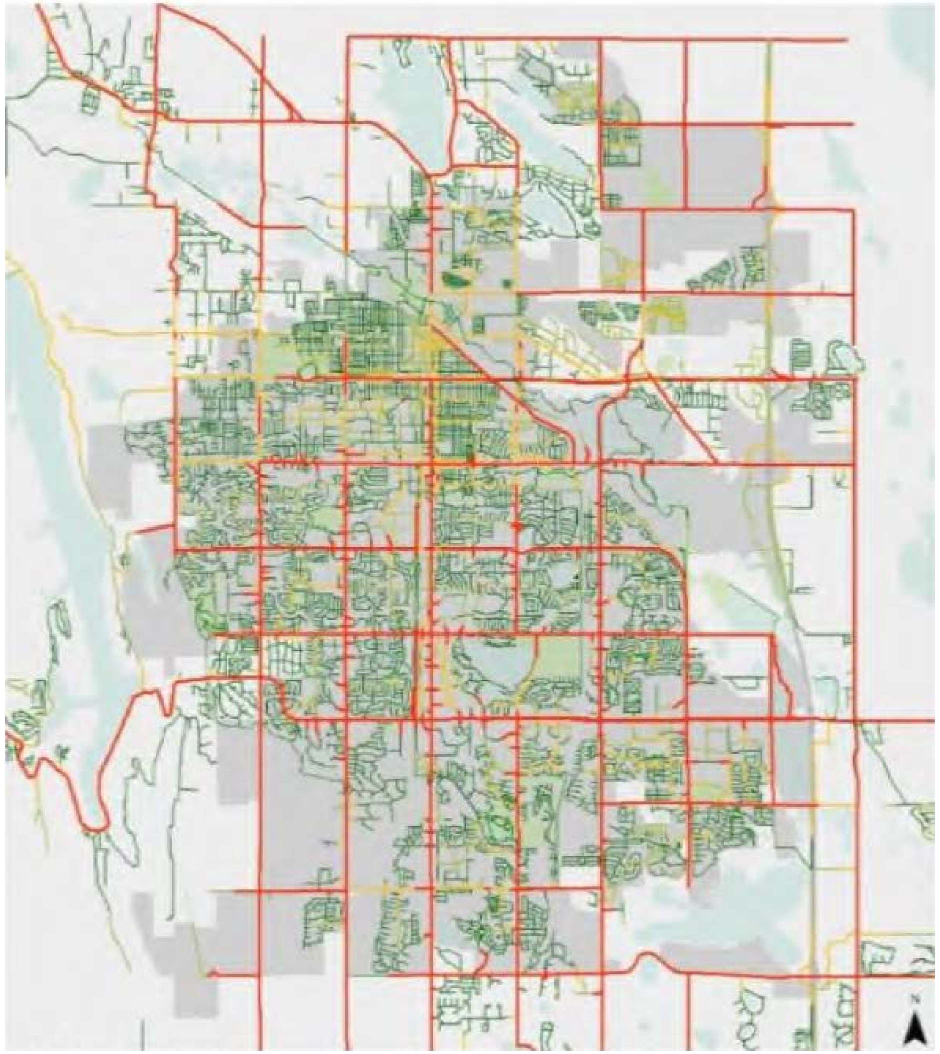
Caltrans District 4

How are our state highways impacting local bicycle access?



City of Fort Collins (CO)

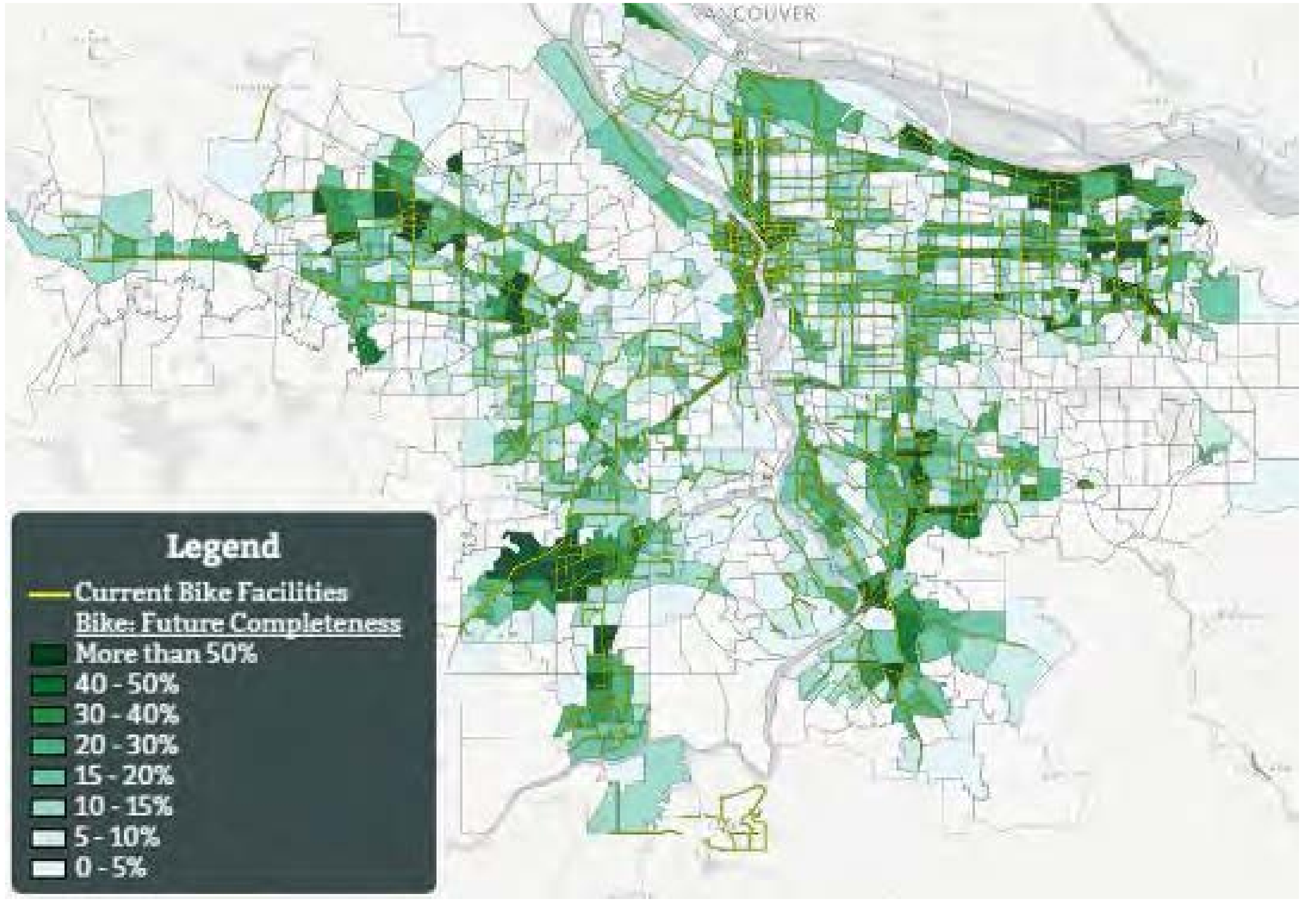
How can we measure bicycle network quality change over time?



Portland Metro

Where are the gaps in regional bike & ped networks?

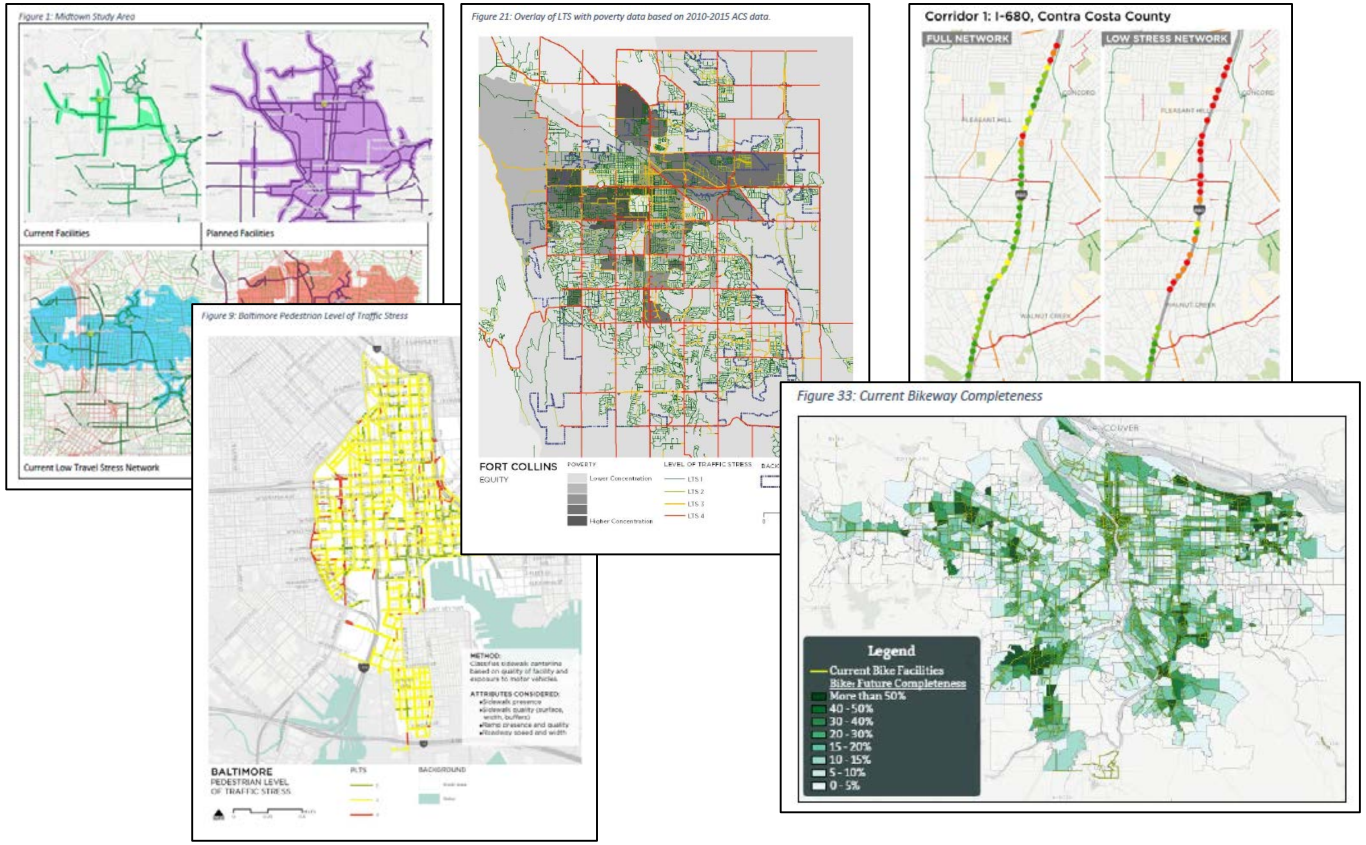
How well does the Regional Transportation Plan address them?



How do we get beyond facility inventories & one-time analyses?

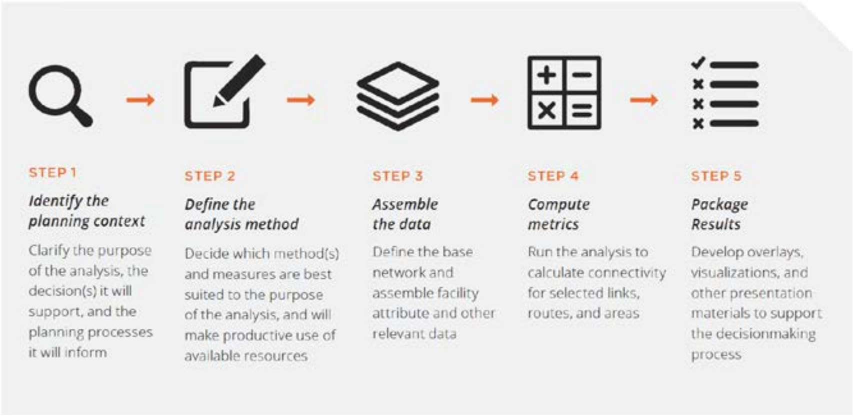
Measuring *connectivity* instead of *quantity* can capture…

- The value of individual facilities (or of missing pieces!) to the network as a whole
- The ability of the network to connect people walking & biking to places they want to go
- The quality of a network, in part or all together



Guidebook goals

- ➢ Define connectivity analysis
- ➢ Scan network connectivity in research & practice
- ➢ Provide menu of bike & ped measures
- ➢ Document in actual planning contexts
- ➢ Transfer lessons learned & recommend best practices



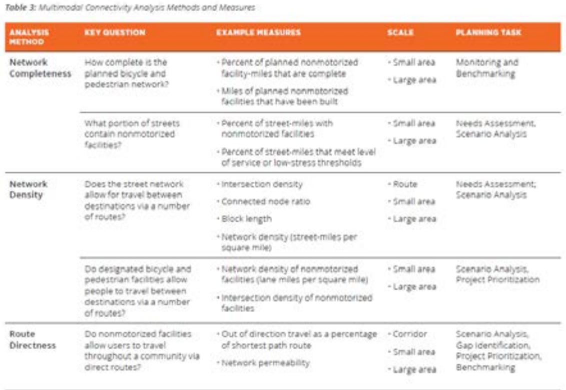
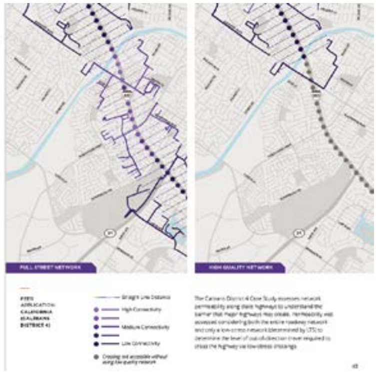
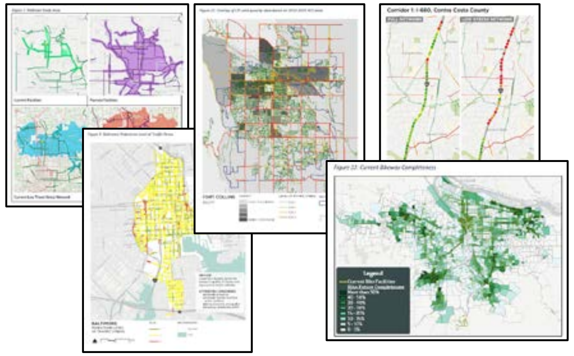


Table 3: Multimodal Connectivity Analysis Methods and Measures

ANALYSIS METHOD	KEY QUESTION	EXAMPLE MEASURES	SCALE	PLANNING TASK
Network Completeness	How complete is the planned bicycle and pedestrian network?	• Percent of planned nonmotorized facility-miles that are complete • Miles of planned nonmotorized facilities that have been built	• Small area • Large area	Monitoring and Benchmarking
	What portion of streets contain nonmotorized facilities?	• Percent of street-miles with nonmotorized facilities • Percent of street-miles that meet level of service or low-stress thresholds	• Small area • Large area	Needs Assessment, Scenario Analysis
Network Density	Does the street network allow for travel between destinations via a number of routes?	• Intersection density • Connected node ratio • Block length • Network density (street-miles per square mile)	• Route • Small area • Large area	Needs Assessment; Scenario Analysis
	Do designated bicycle and pedestrian facilities allow people to travel between destinations via a number of routes?	• Network density of nonmotorized facilities (lane miles per square mile) • Intersection density of nonmotorized facilities	• Small area • Large area	Scenario Analysis, Project Prioritization
Route Directness	Do nonmotorized facilities allow users to travel throughout a community via direct routes?	• Out of direction travel as a percentage of shortest path route • Network permeability	• Corridor • Small area • Large area	Scenario Analysis, Gap Identification, Project Prioritization, Benchmarking





LESSONS LEARNED

To support the development of this guide, FHWA reached out to numerous transportation planners through webinars, interviews, and focus groups for input and advice about their experiences with analyzing multimodal connectivity. The research team also worked directly with five agencies to conduct assessments that involved the methods and measures described in this guide. The comments in this chapter are a synthesis of reflections and suggestions from both the case study participants and other peer participants in this research. More specific details on the processes conducted and lessons learned by each case study agency are included as an appendix to this guide.

STEP 1: IDENTIFYING THE PLANNING CONTEXT

- Articulate a clearly defined network vision and analysis goal to help

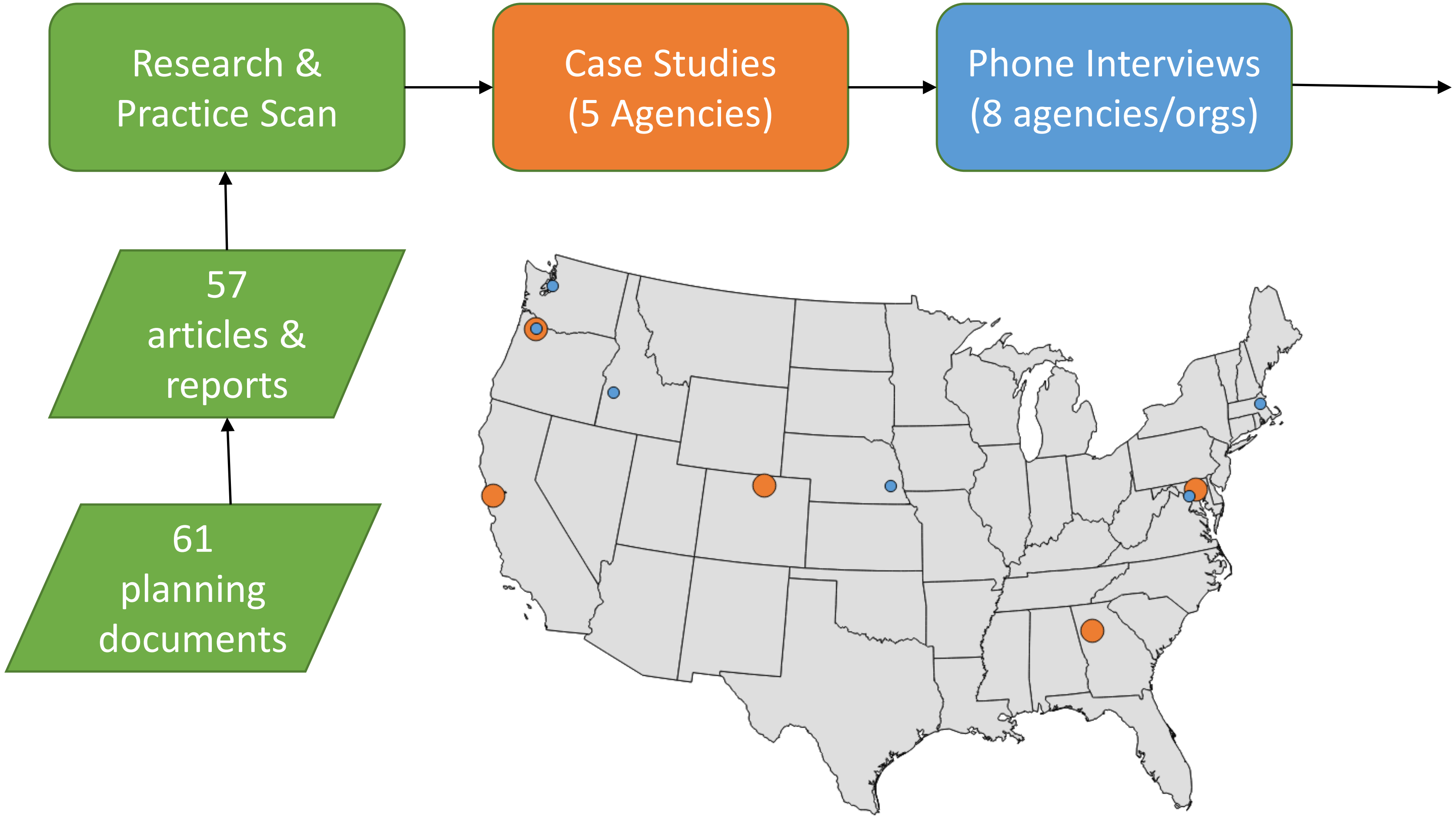
STEP 2: DEFINING THE ANALYSIS METHOD

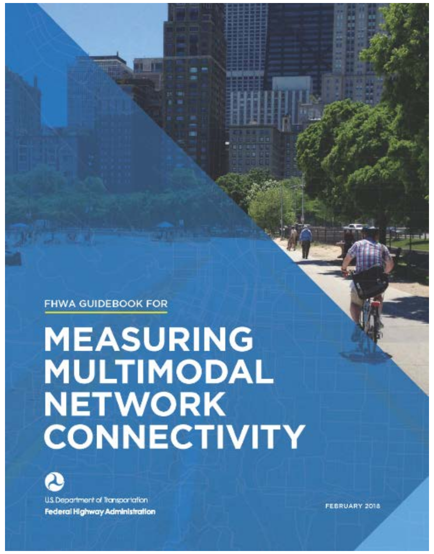
- Select a method appropriate for the intended application. Refer to the planning context identified in Step 1 that defines how the analysis will be used in order to help determine the appropriate analysis method and measures. Consider how the measures and analysis results could be used over time and in conjunction with other processes to help fine-tune the decision.
- To enhance accountability, select measures that can be tracked over time. Taking into account the potential availability of data for future analyses, and the possibility that the measures or analysis parameters might need to be changed over time, select measures that are likely to be useful, replicable, and comparable for years to come.
- Select methods and measures

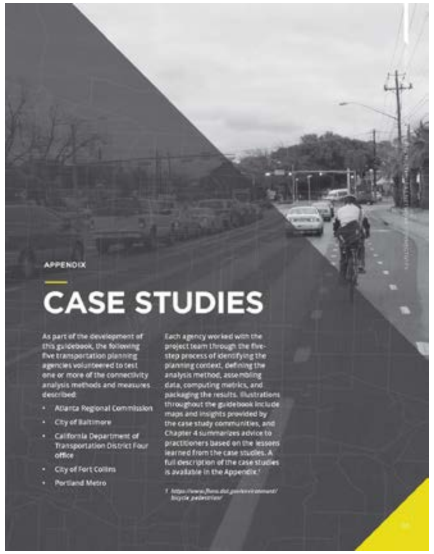
facilities do or could exist on the ground. More complex approaches such as low-stress indices enable planners to consider the benefits of recent or potential improvements to a mature network. For example, the bicycle and pedestrian network in many areas of the Portland region is largely built out. Metro uses low-stress analyses to help set priorities for filling gaps and improving existing facilities rather than focusing on building new facilities. In rural communities or newly growing suburbs, the network may be too sparse to allow for meaningful analyses of detailed connectivity measures such as stress indices.

- Consider potential implications when modifying existing methods and measures. Agencies commonly adapt connectivity measures to fit available data and technical capacity. This is understandable given the complexity of some measures, but it can make results harder to compare over time,

Methodology

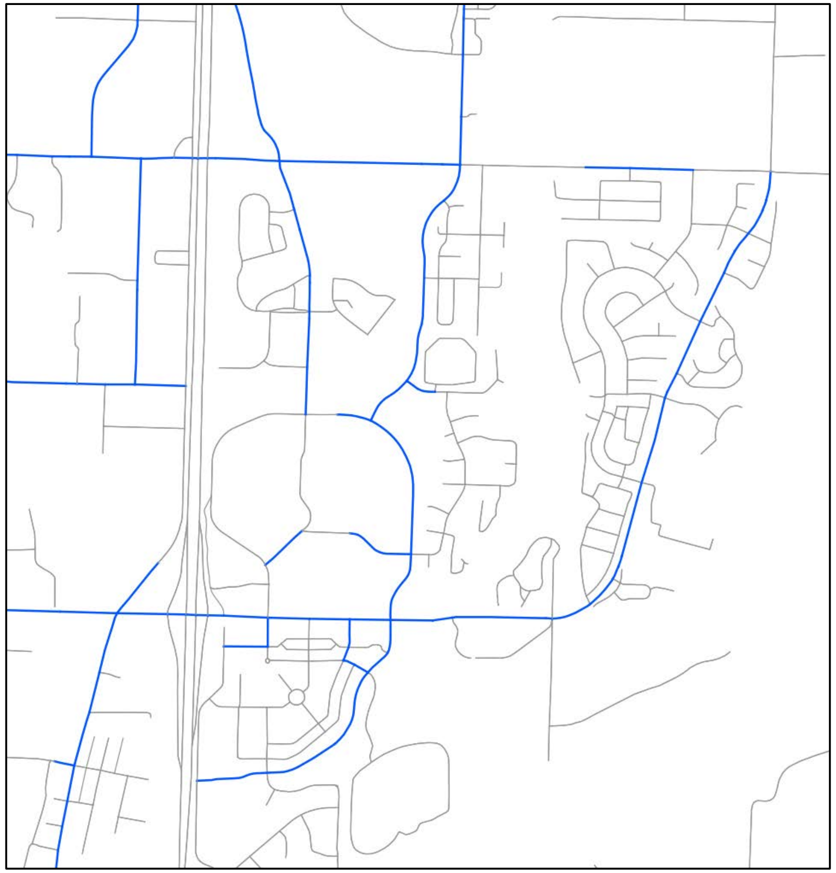




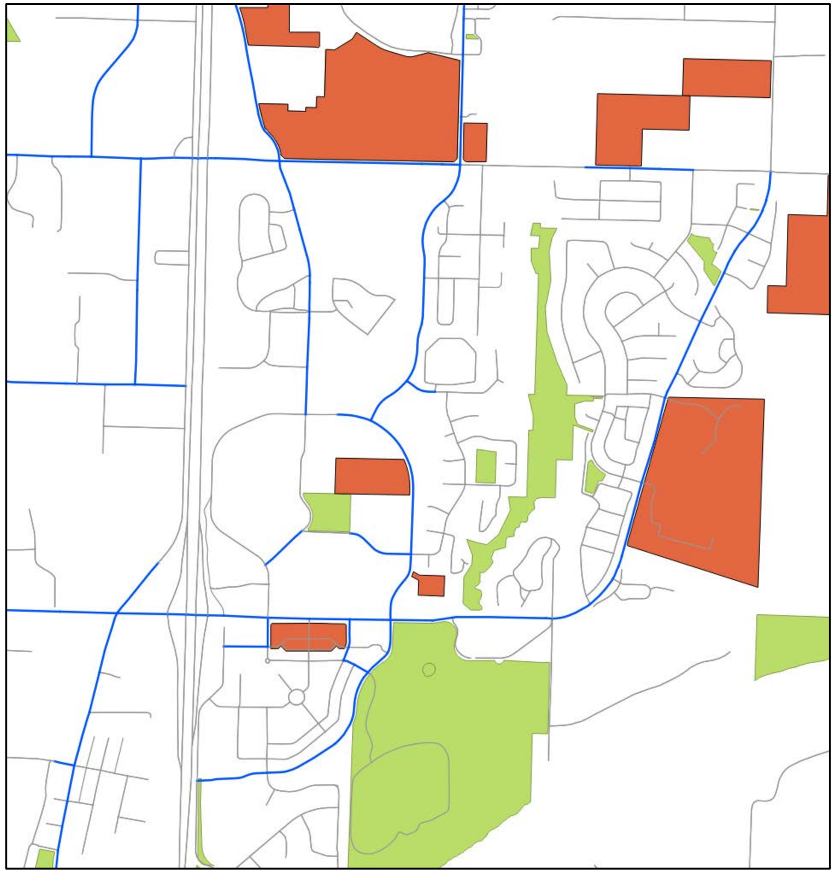


Network connectivity: you know it when you see it?

Network connectivity: what if we add bike lanes and bike boulevards?

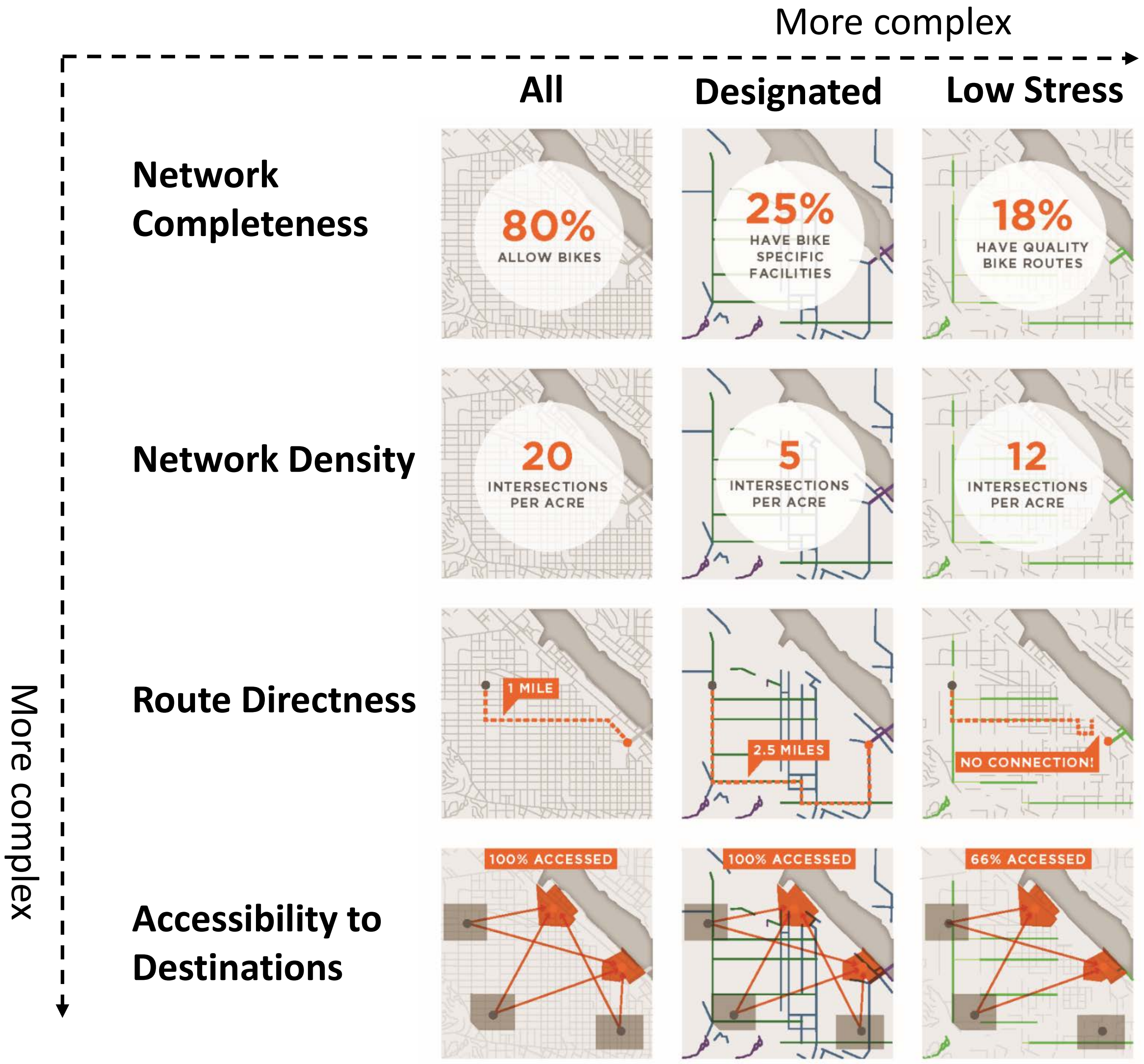


Network connectivity: how about schools & parks??



It depends on how you measure it

- We organized into 4 general analysis methods
- Facility Type or Quality Measures may be added to any of the methods.



Connectivity Analysis Process

STEP 1

Identify the planning context

Clarify the purpose of the analysis, the decision(s) it will support, and the planning processes it will inform

STEP 2

Define the analysis method

Decide which method(s) and measures are best suited to the purpose of the analysis, and will make productive use of available resources

STEP 3

Assemble the data

Define the base network and assemble facility attribute and other relevant data

STEP 4

Compute metrics

Run the analysis to calculate connectivity for selected links, routes, and areas

STEP 5

Package Results

Develop overlays, visualizations, and other presentation materials to support the decisionmaking process

Planning Context

We identified roles for connectivity analysis throughout the planning process via:

Simpler…

- Gap identification
- Needs assessment

Moderate…

- Monitoring & Benchmarking

More Difficult…

- Scenario analysis
- Project prioritization

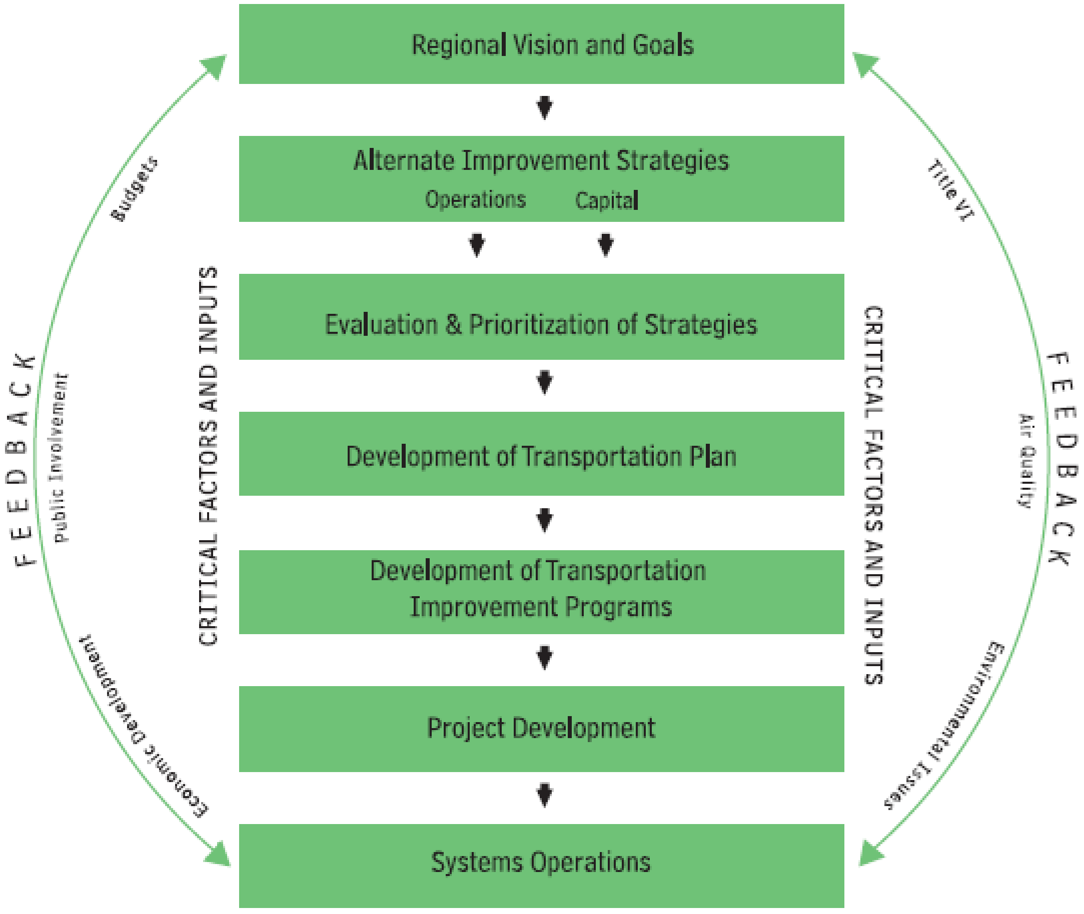


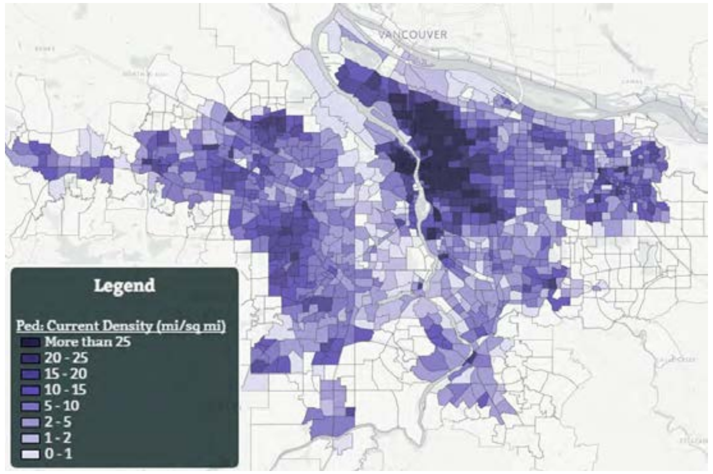
***Figure 1.** Transportation Planning, Decisionmaking and Implementation.*
Source: U.S. Department of Transportation. 2016. "The Transportation Planning Process Briefing Book." https://www.fhwa.dot.gov/planning/publications/briefing_book

Analysis Method

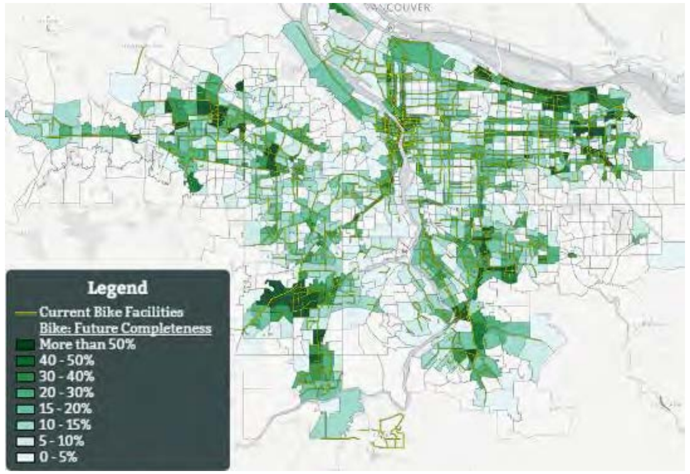
Four types, falling into two major categories

- Form-based
  - Calculated over defined area
  - Measures mainly *potential* connectivity
  - Low to moderate complexity
- Route-based
  - Calculated between sets of origins & destination
  - More closely measures *realized* connectivity
  - Moderate to high complexity

Form-based

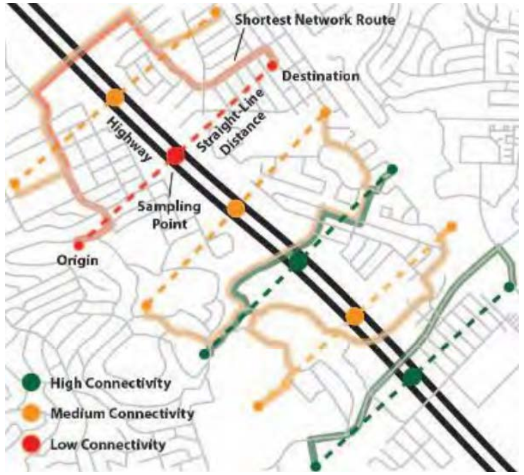


Sidewalk Density

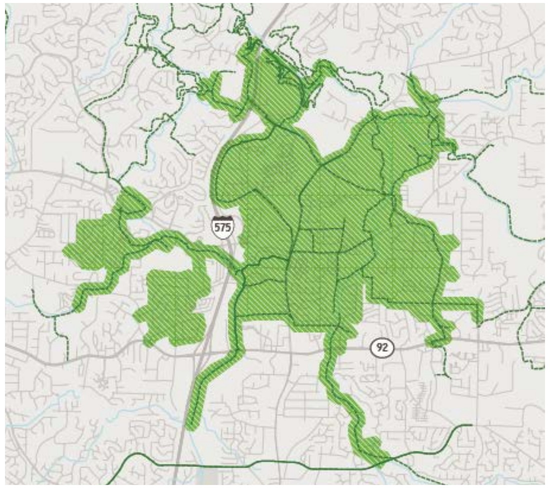


Bicycle Facility Completeness

Route-based



Route Directness

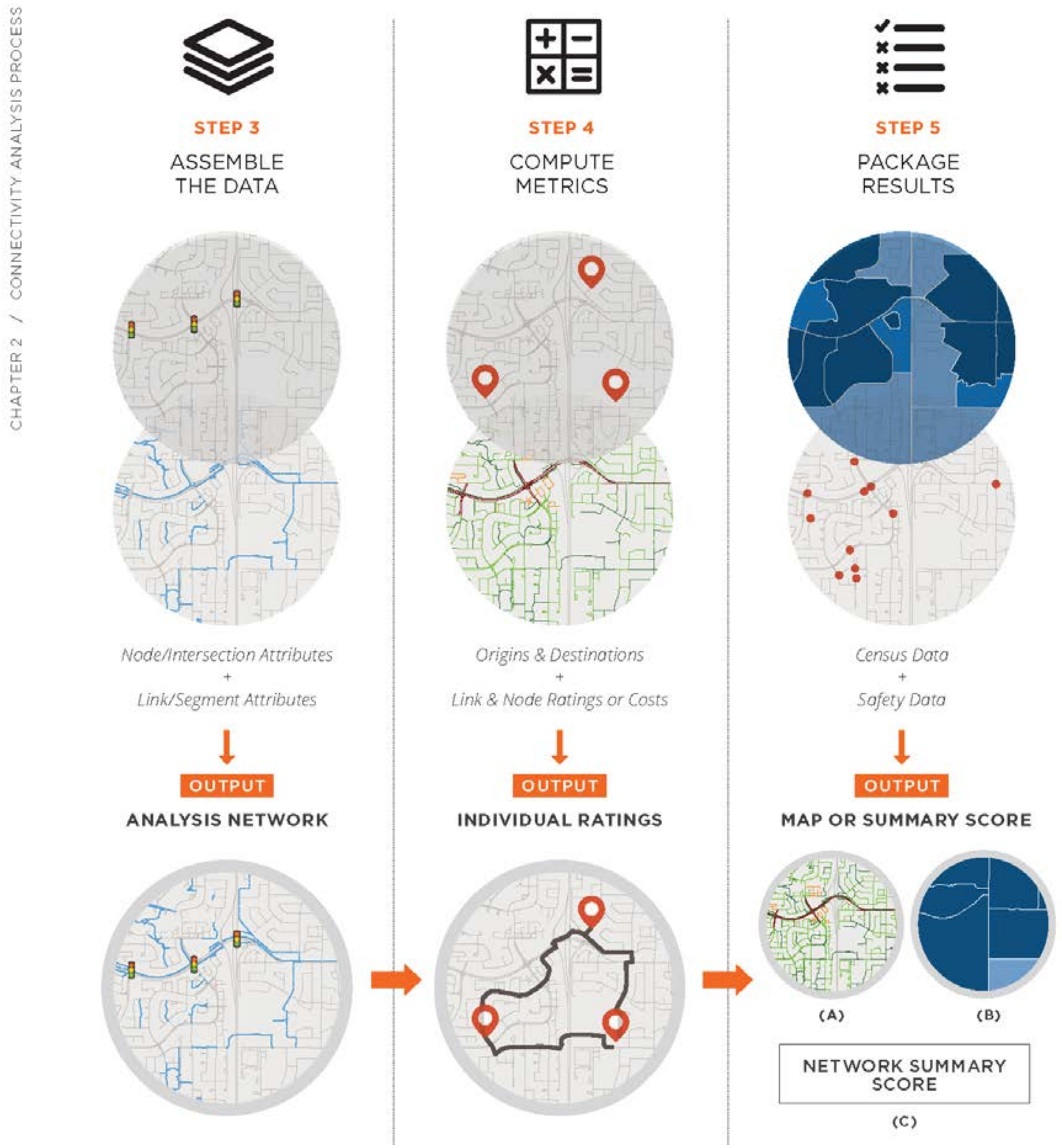


Access to Destinations

Measuring Connectivity: Data

Data varies by context & method

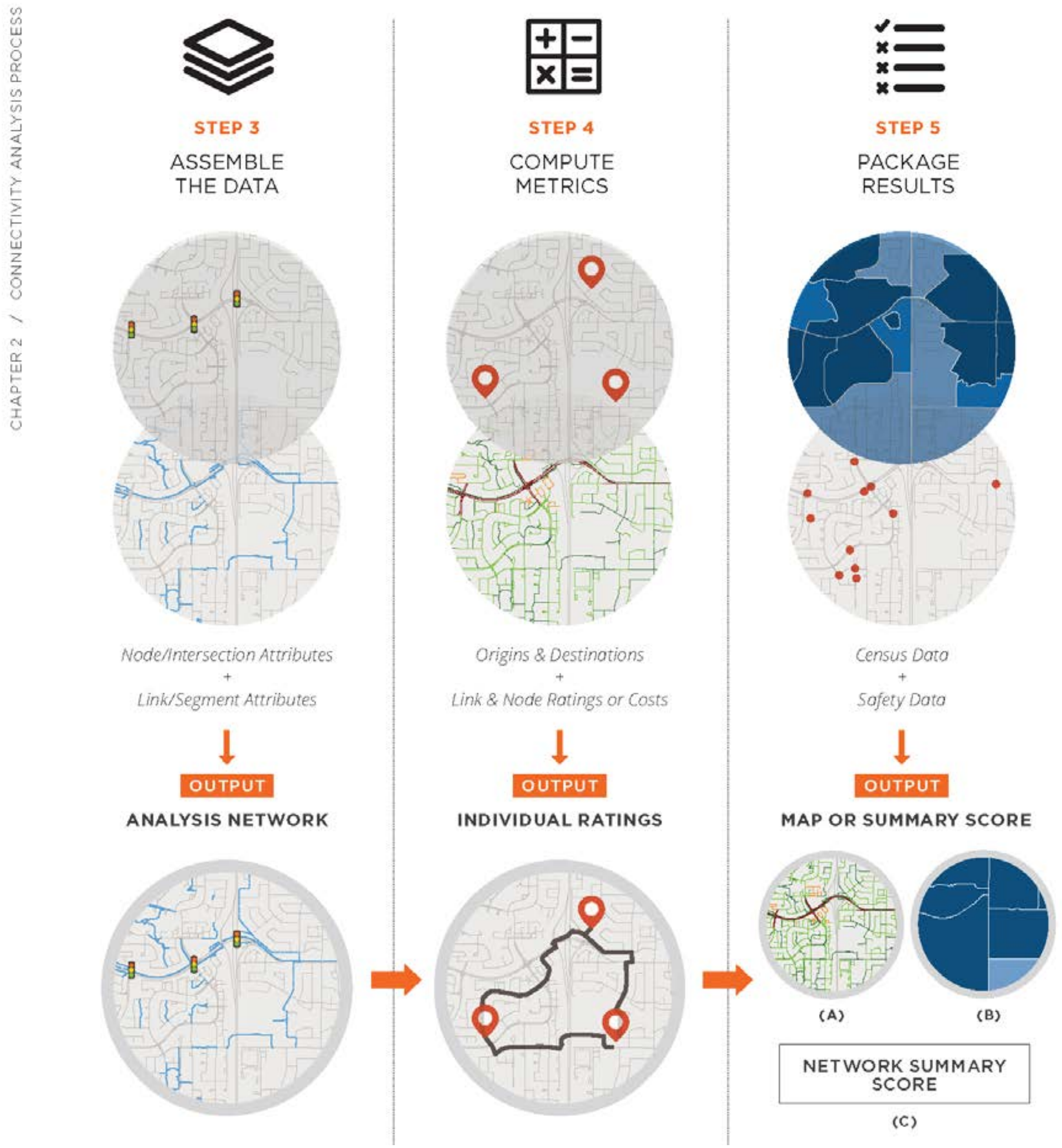
- ➢ Bike & Ped Facility Data
  - ➢ Designated facility types
  - ➢ Intersection features
  - ➢ Slope (terrain)
- ➢ Supporting Data
  - ➢ Roadway design characteristics
  - ➢ Traffic volume and/or speed
  - ➢ Heavy vehicle traffic
  - ➢ Potential obstacles (e.g. driveways)



Measuring Connectivity: Metrics

Network component ratings

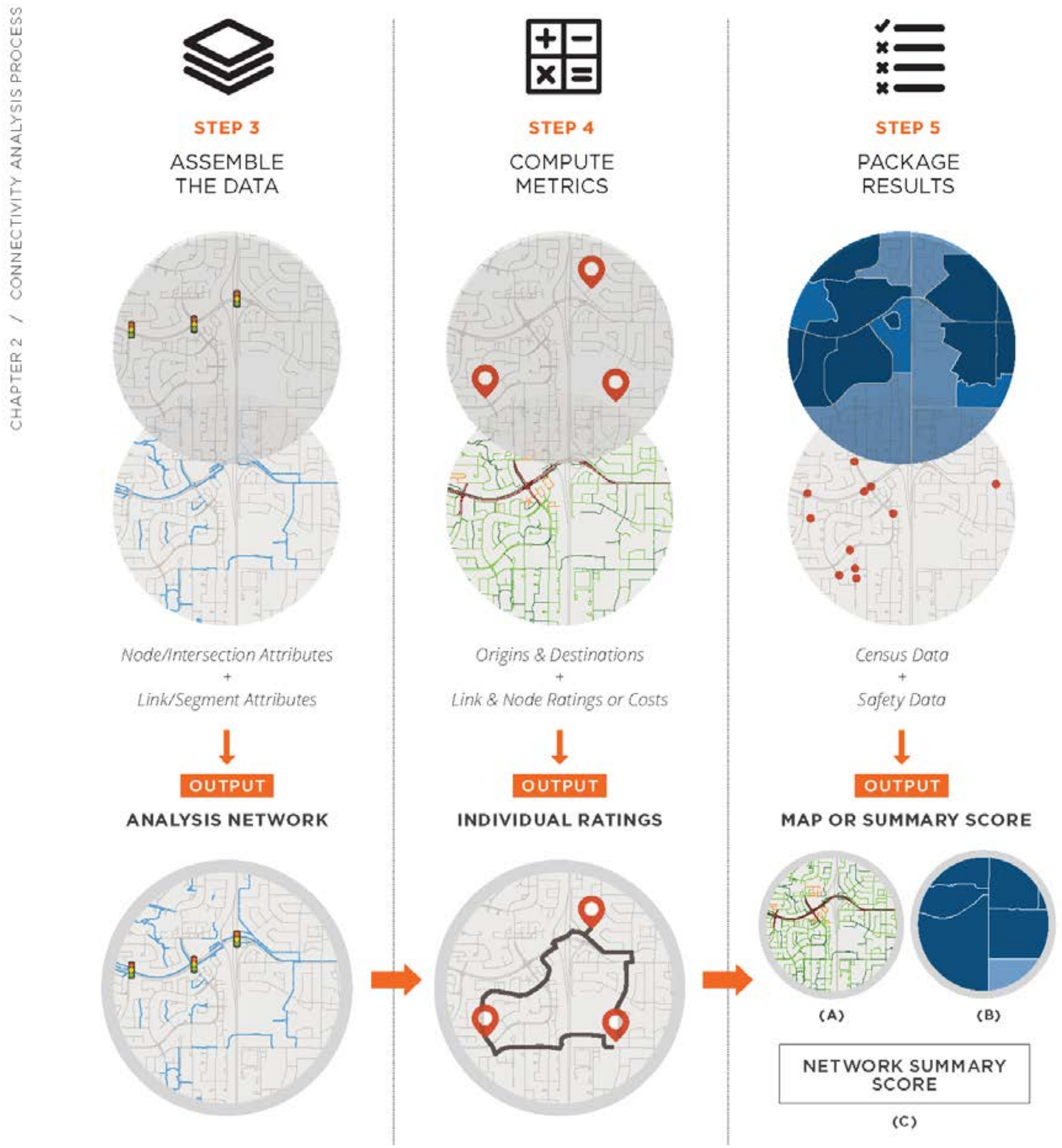
- Individual segments
  - All
  - All meeting threshold
  - Quality/preference weighted
- Routes
  - Entire network (self-connectivity)
  - From single point (travelshed)
  - Between specific origins and destinations



Measuring Connectivity: Package

Aggregate the component scores

- Map
- Small area score
- Network summary score

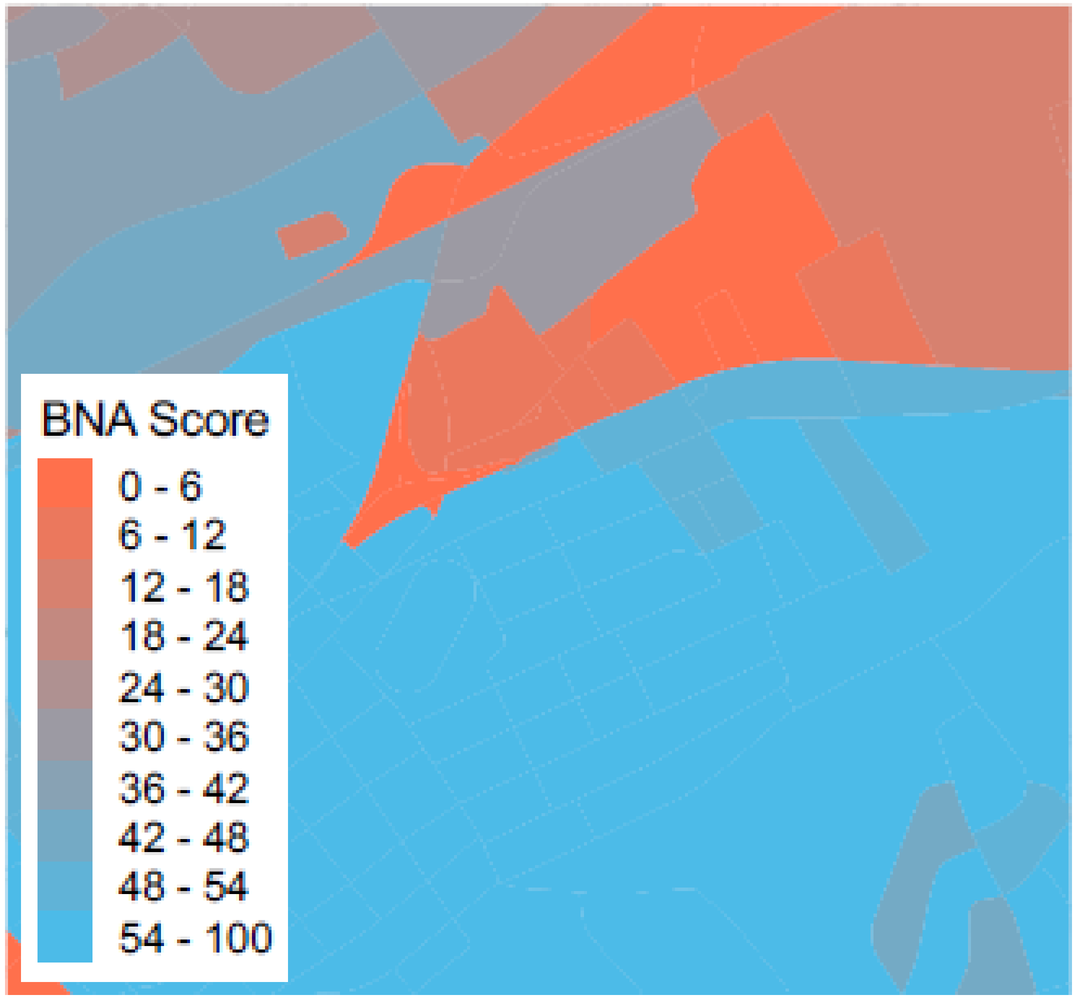


Simple Mapping

- Visual analysis is common to identify network gaps & opportunities
- At right, results of a network segment & intersection quality rating (Route Quality Index)
- Difficult to make objective comparisons

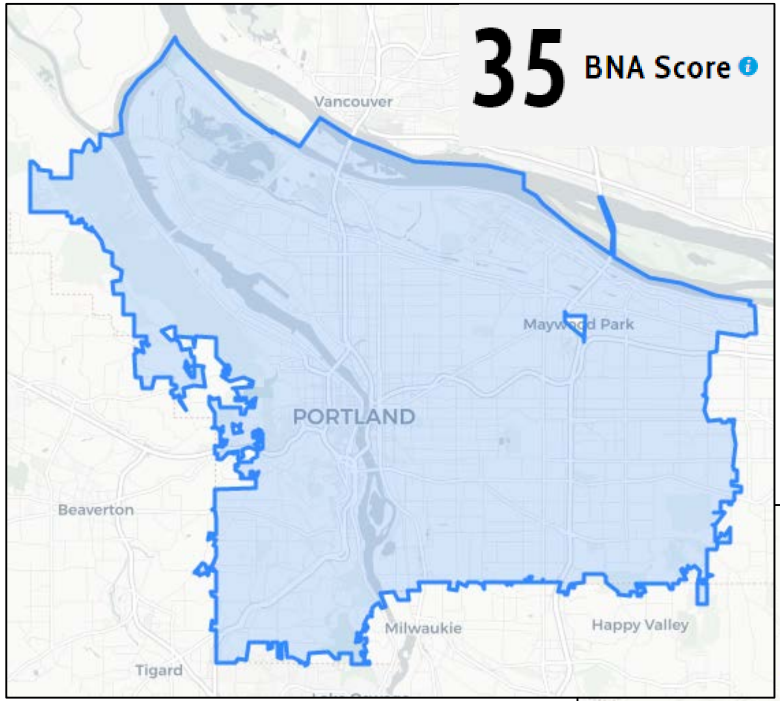
Small Area Scores

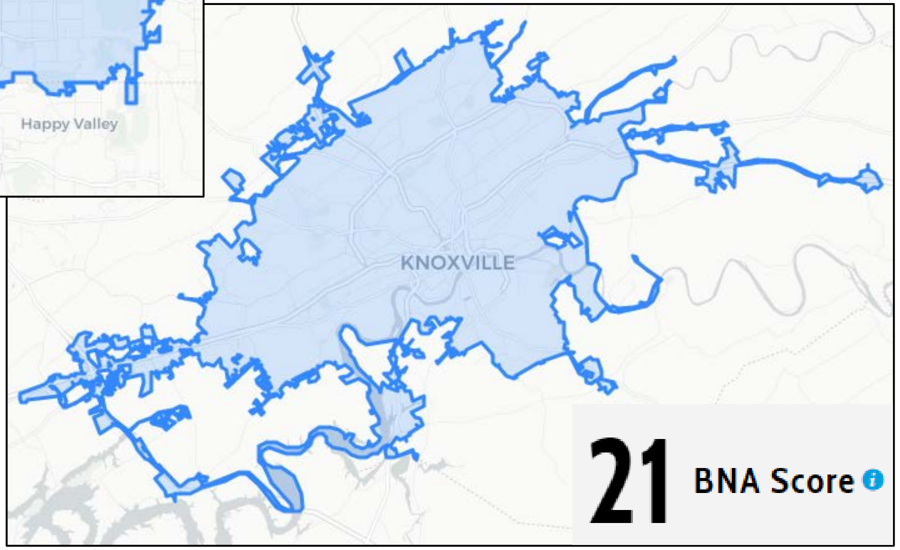
- Scores for many segments or routes can be summarized to small areas.
- At right, access to a basket of destination types is shown for each census block (People for Bikes BNA tool).
- Small area scores are easier to compare across areas or over time.



Network Summary Scores

- Depending on the planning context and method, scores can be summarized to the entire network.
- The results at right are based on population-weighted small area scores for entire regional bike networks (People for Bikes BNA)
- Network scores are comparable over time or between different networks (current/planned or across regions)



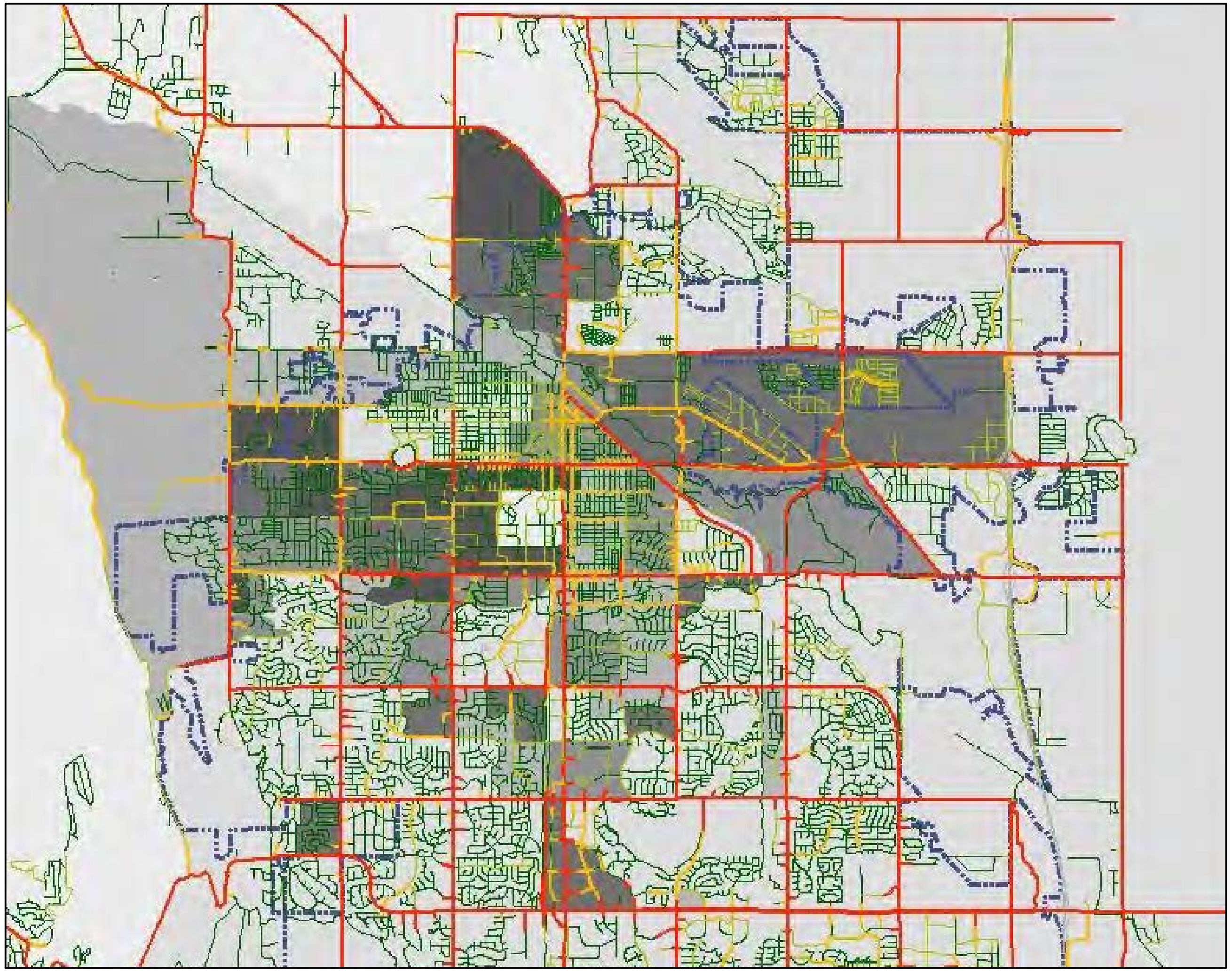


Overlays

Connectivity results can be overlaid with other data to suit the planning context or for additional analysis

- Sociodemographics (equity)
- Crash data (safety)
- Use data (demand)

At right, poverty rates are overlaid on bicycle network quality (Level of Traffic Stress)



Method & Measure Fact Sheets

CONNECTIVITY MEASURE

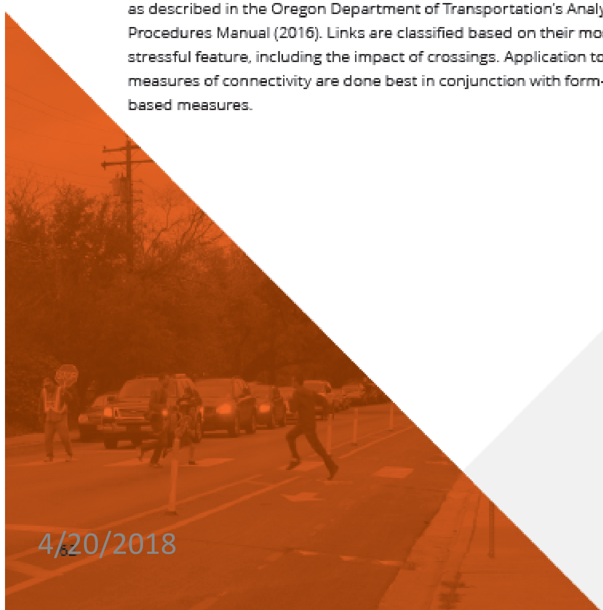
PEDESTRIAN LEVEL OF TRAFFIC STRESS (PLTS)

What is the extent to which pedestrians feel safe and comfortable using the network?

MODE	METHOD	OUTPUTS	CONNECTIVITY ANALYSIS METHODS	ACCESSIBILITY	USE IN PRACTICE	LEVEL OF EFFORT
Pedestrian	Classify sidewalk segments by type by highest stress attribute	Pedestrian stress rating of 1 through 4 for sidewalk centerline and intersections	Directness, Accessibility to Destinations, Quality	Explicit consideration of accessibility for people with disabilities: Yes	Emerging	HIGH

DESCRIPTION

Pedestrian LTS measures indicate the relative level of comfort for pedestrians using a given network, taking into account the variety of abilities and trip purposes among different types of people. The categories of pedestrian traveler characteristics, including user types and trip purposes, are similar to those developed for Bicycle LTS measures. Criteria and thresholds are customized for pedestrians, as described in the Oregon Department of Transportation's Analysis Procedures Manual (2016). Links are classified based on their most stressful feature, including the impact of crossings. Application to measures of connectivity are done best in conjunction with form-based measures.

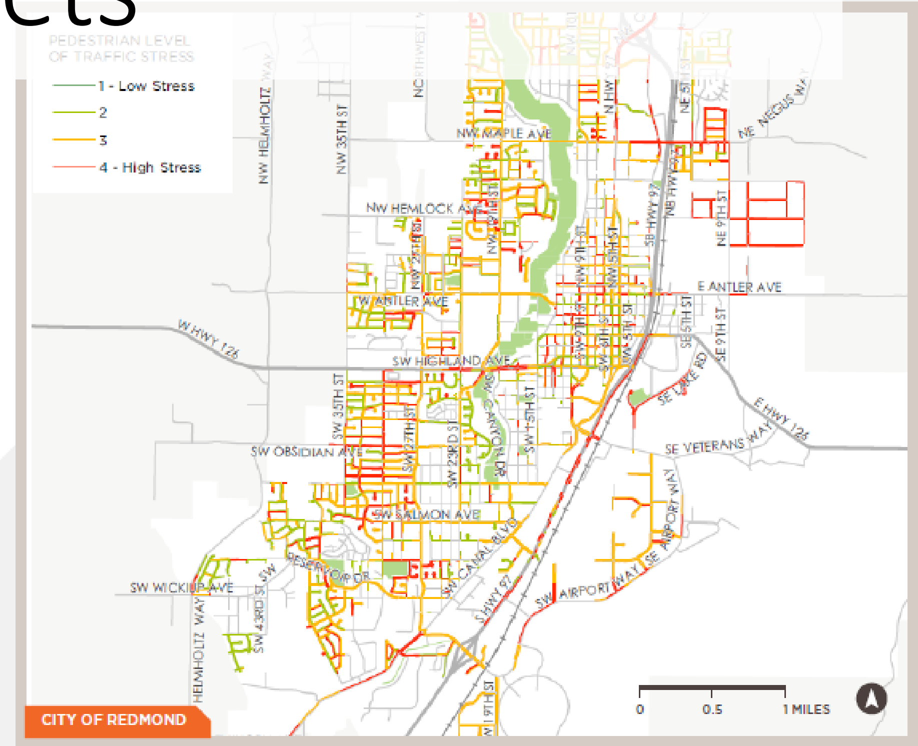


EXAMPLE PLANNING APPLICATION(S)

- To identify factors that contribute to low- and high-stress corridors and routes
- To set priorities for locations that need specific types of improvements

TYPICAL DATA

- Sidewalk centerlines, widths, surface types, surface quality
- Crossing locations, marking, lighting
- Curb ramps and other infrastructure supporting access for people with disabilities
- Motorized traffic data: Traffic volumes, traffic speeds
- Street network data: Number of lanes, lane width, width of paved shoulder, presence of curbs, on-street parking
- Pedestrian origins and destinations



Steve Faust and Anais Mathez, Cogen Owens Green to Deborah McMahon, City of Redmond. May 22, 2017. Redmond Neighborhood Revitalization Plan: Draft Technical Memorandum #1 Existing and Future Conditions.

PEER APPLICATION

- In Oregon, Pedestrian LTS is the preferred method defined by the DOT for Regional Transportation Plans and Transportation System Plans. It can also be used on a screening-level basis for project development and development review. The recommended PLTS measurement methodology will be outlined in the updated ODOT Analysis Procedures Manual. [1]

ADVANTAGES

- Provides a comparable measure to BLTS
- Provides a detailed understanding of individual sidewalk centerline segments and provides visually descriptive picture of physical conditions
- The tool is sensitive to disability access concerns, including ramp quality and surface quality
- It allows adjustments for additional treatments or infrastructure intended to improve the pedestrian environment

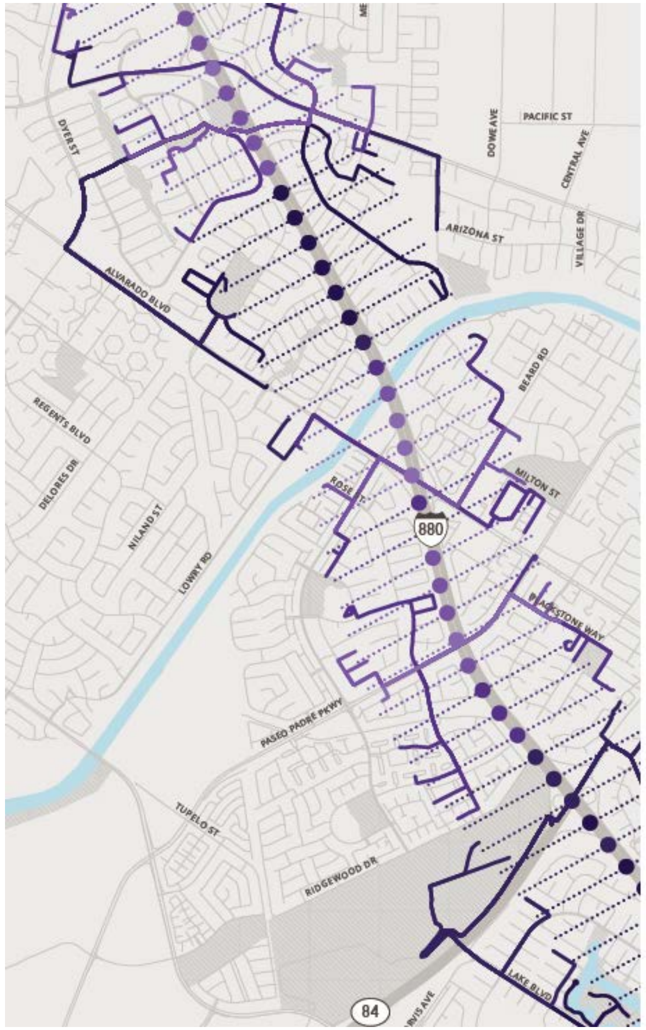
CONSIDERATIONS

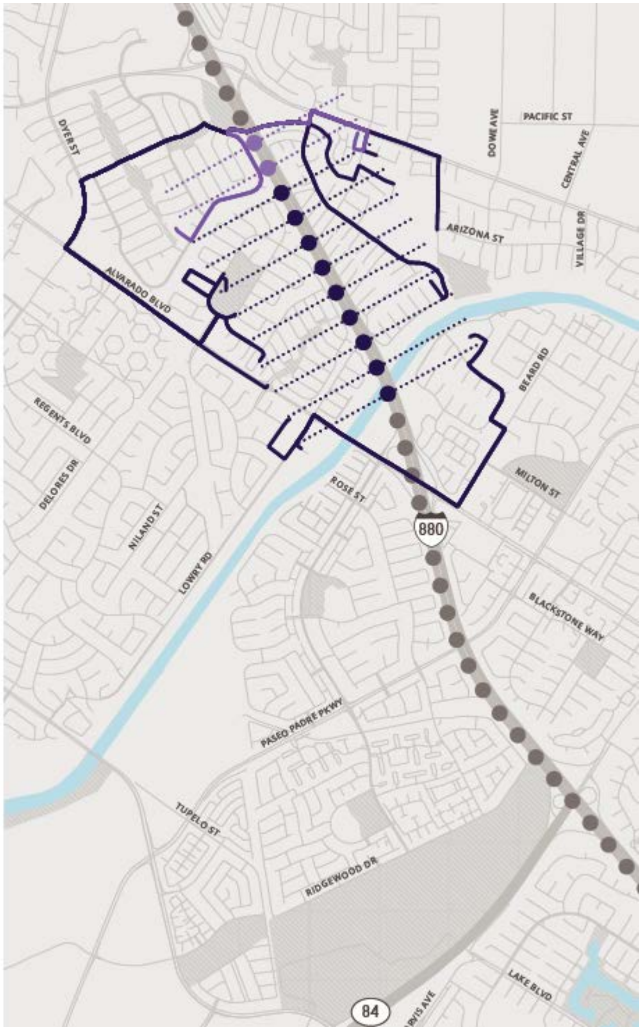
- The tool is data-intensive
- The data cannot easily be used
- The results are not validated against behavior/use data
- The classification is sensitive only to "weakest link" improvements
- The current methodology precludes improvements in certain areas based on land use types
- In rural areas, the definition of sidewalks and criteria within the measure may need to be adjusted to reflect nonurban characteristics

1 *http://www.oregon.gov/ODOT/Planning/Pages/APM.aspx*

Case Study: Caltrans District 4

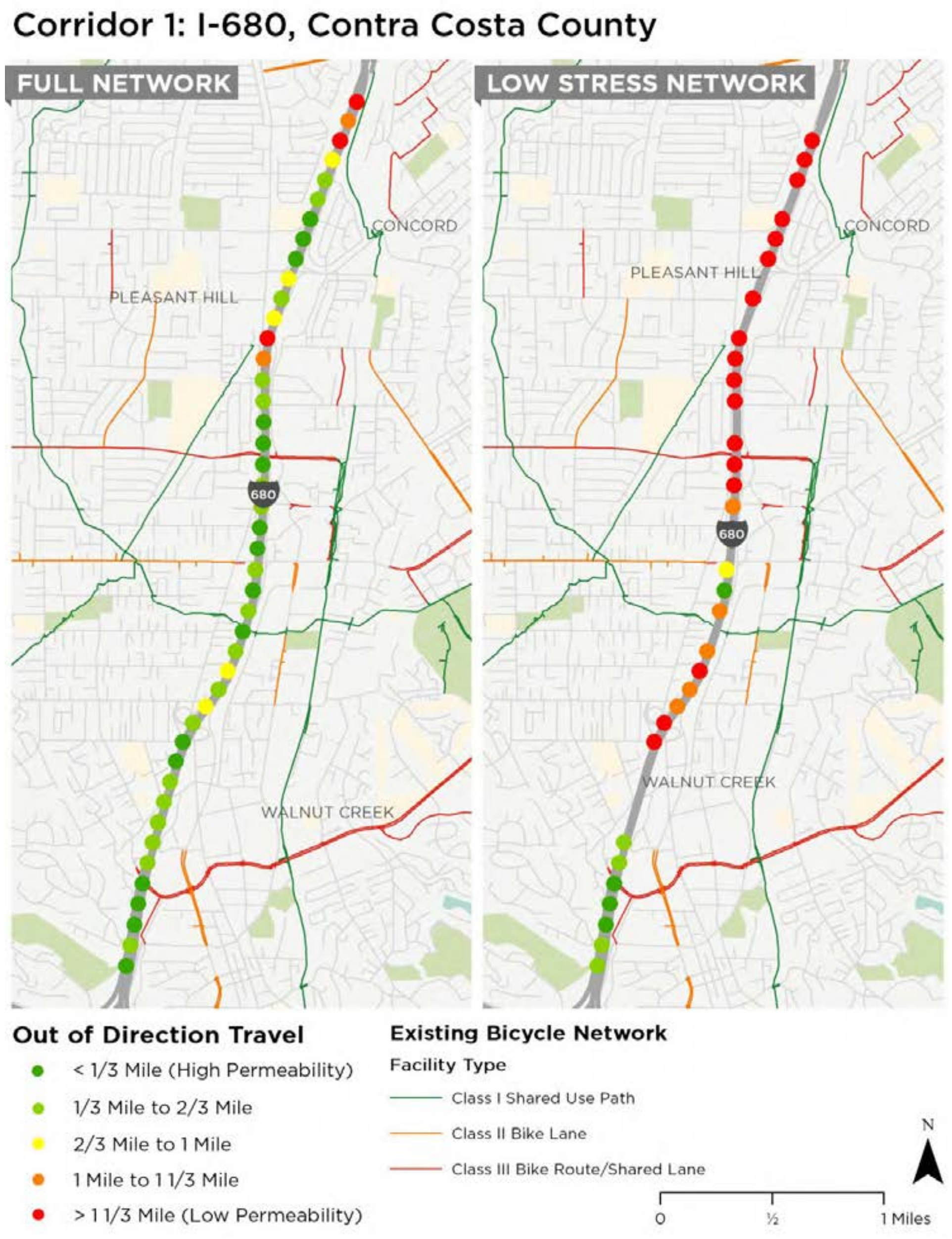
- **Context**: Measure bicycle mobility across state highway corridors (project planning, prioritization, funding, and benchmarking)
- **Method**: Route directness
- **Data**: Routable bike network, state highways, and supporting
- **Metrics**: Shortest paths along low-stress segments





Case Study: Caltrans District 4 Results (map)

- Maps for each corridor w/ individual crossing scores.



Case Study: Caltrans District 4 Results (summary scores)

- Summary scores for corridor by directness level
- Could be compared between corridors and over time
- Could also calculate a summary for all corridors in jurisdiction to benchmark overall performance over time.

Agency plans to add bike & ped permeability scores to its 20-year planning process.

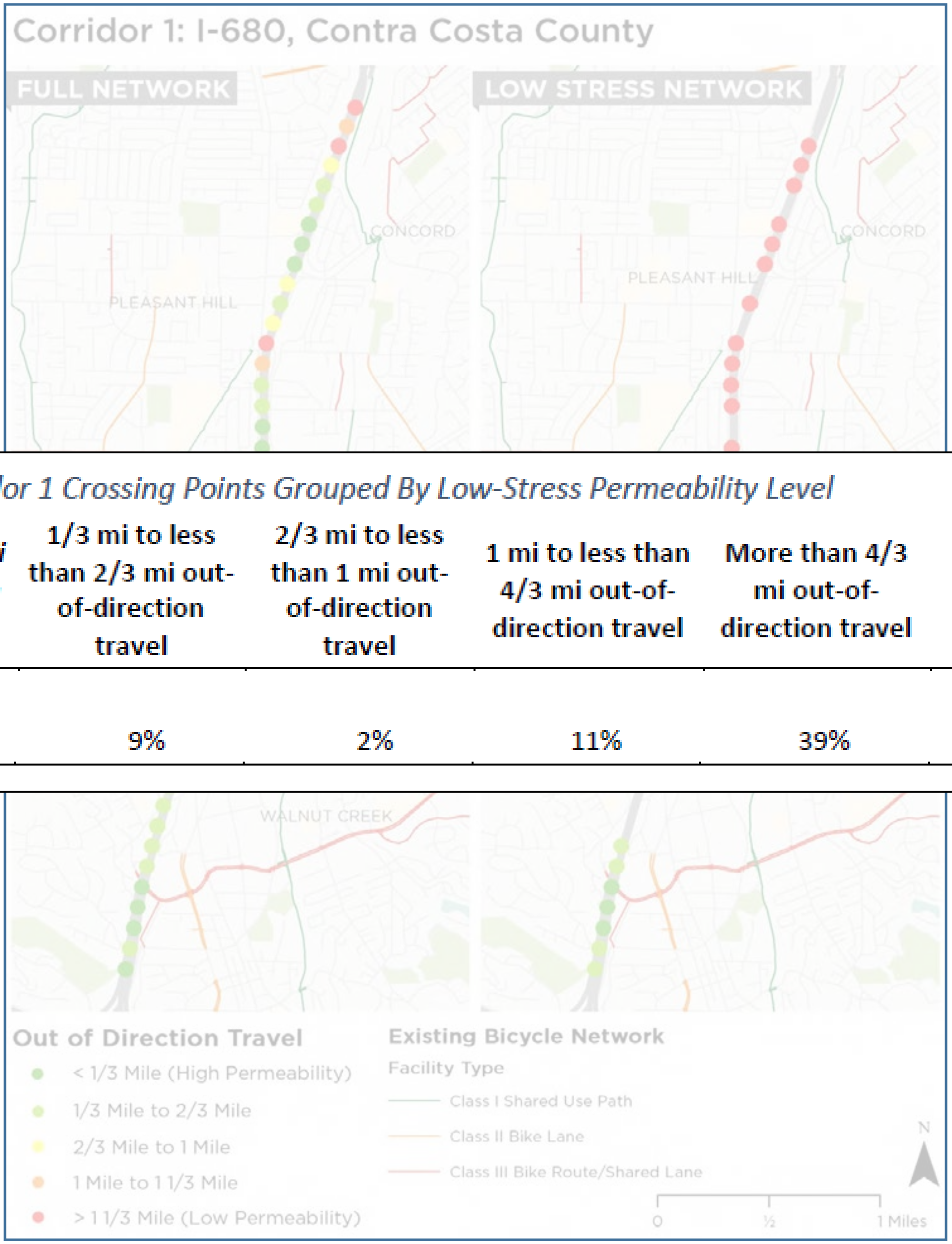


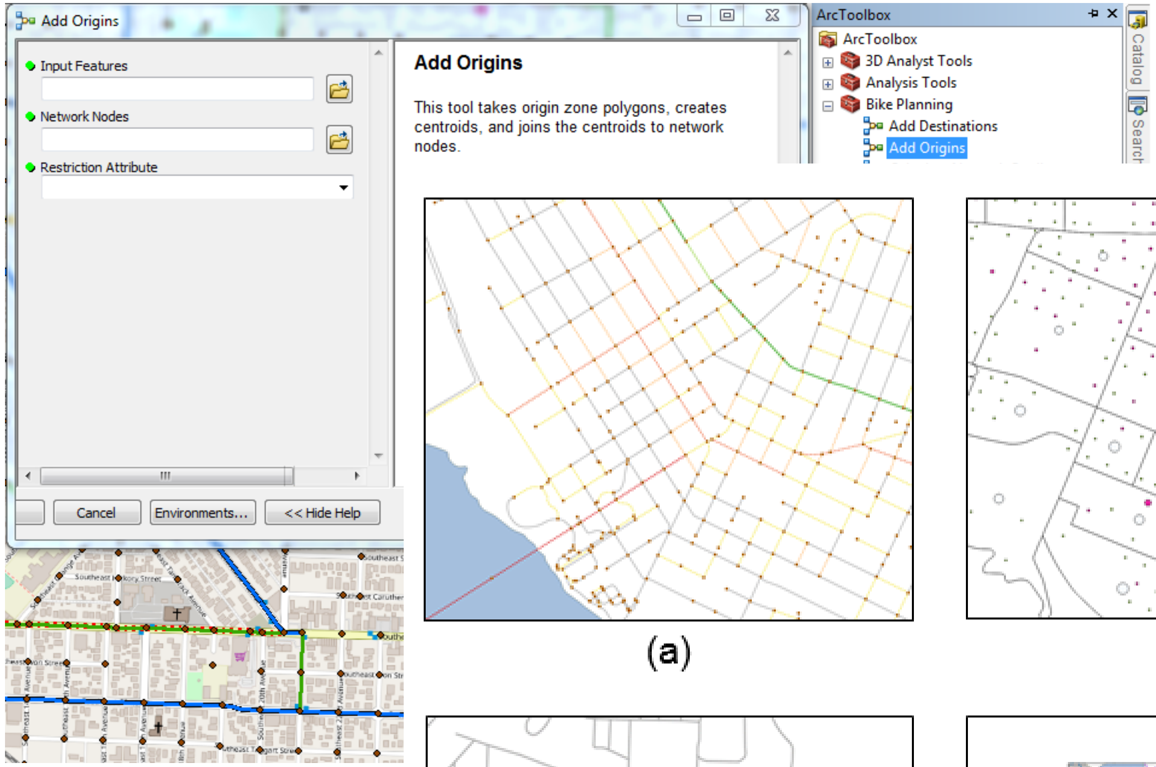
Table 10: Corridor 1 Crossing Points Grouped By Low-Stress Permeability Level

Less than 1/3 mi out-of-direction travel	1/3 mi to less than 2/3 mi out-of-direction travel	2/3 mi to less than 1 mi out-of-direction travel	1 mi to less than 4/3 mi out-of-direction travel	More than 4/3 mi out-of-direction travel	No Low-Stress Path
9%	9%	2%	11%	39%	30%

- Connectivity goals common; measurement less so
- Mostly visual/qualitative
- More common & more advanced methods for bicycling
- Intersections often omitted
- Mostly urban
- Measures often modified
- Data standards & archiving lacking
- Lack of validation for many measures
- Agencies excited about possibilities!

What's Next? (beyond the guidebook)

- Improved data standards
- "Turnkey" connectivity analysis tools
- Continued research and validation of connectivity measures
  - Use
  - Safety
  - Preference



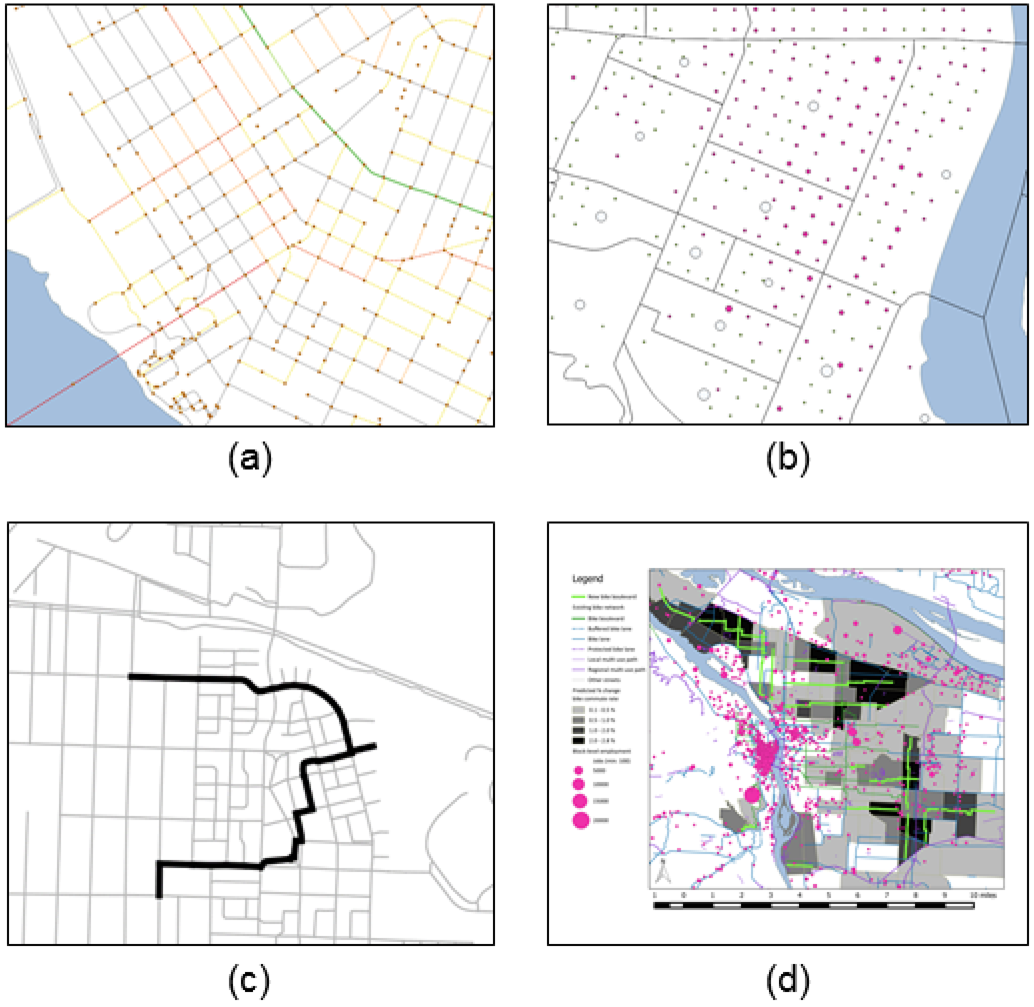


Figure 1 Four Core Components of GIS Planning Tool

More Information

- Download the guidebook & Case study reports https://tinyurl.com/yauxeufw
- Joe: http://orcid.org/0000-0001-7753-501X (research) | jbroach@pdx.edu
- Related FHWA work https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/
- Related work at TREC

http://nitc.trec.pdx.edu/research/projects/search?subject=Bicycling

http://nitc.trec.pdx.edu/research/projects/search?subject=Walking