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How ACS Data Can Make Smart Cities Even Smarter:

A method for combining bike sensor data with ACS demographic data

Peter Viechnicki, Deloitte Center for Government Insights, 12 May 2017
pviechnicki@deloitte.com, @pviechnicki

As Cities get 'Smarter', Sensors Proliferate

"The Instrumented Environment"

Solving the Mobility Problem: means helping citizens get around cheaply, efficiently, safely

Cities are installing **sensors** to monitor flows of many kinds of traffic:

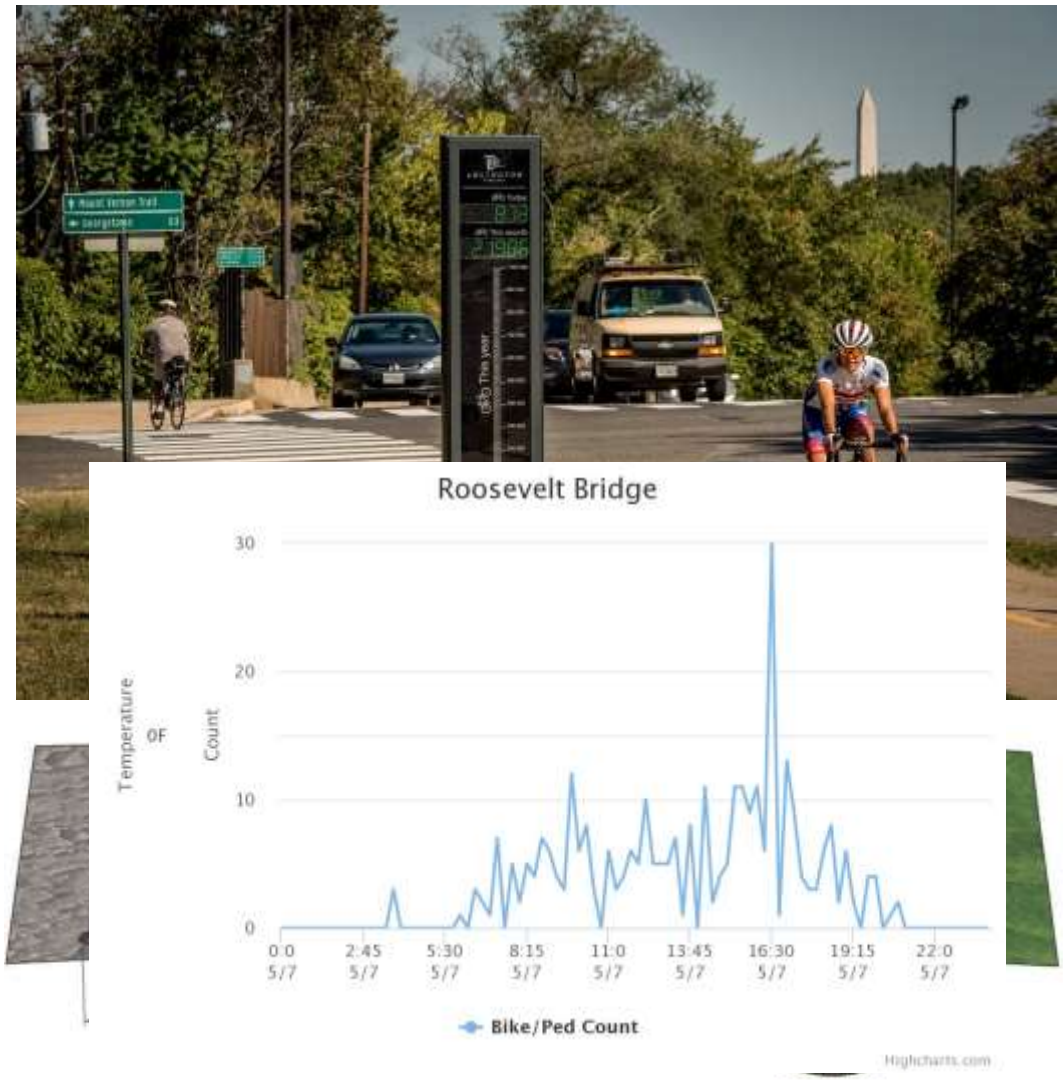
- Automobile
- Transit
- Bikers / Pedestrian

BUT: Having a flood of new data doesn't always clarify things…

The solution? Connecting demographic baseline data to sensor data can help derive meaning from this welter of information.

The Bottom Line: In this presentation we'll show how we can use dimensionality reduction techniques and spatial overlays to connect ACS data to bike counter data from the Washington DC region.

Our method provides a clearer story from the bike counter data than is possible without ACS.

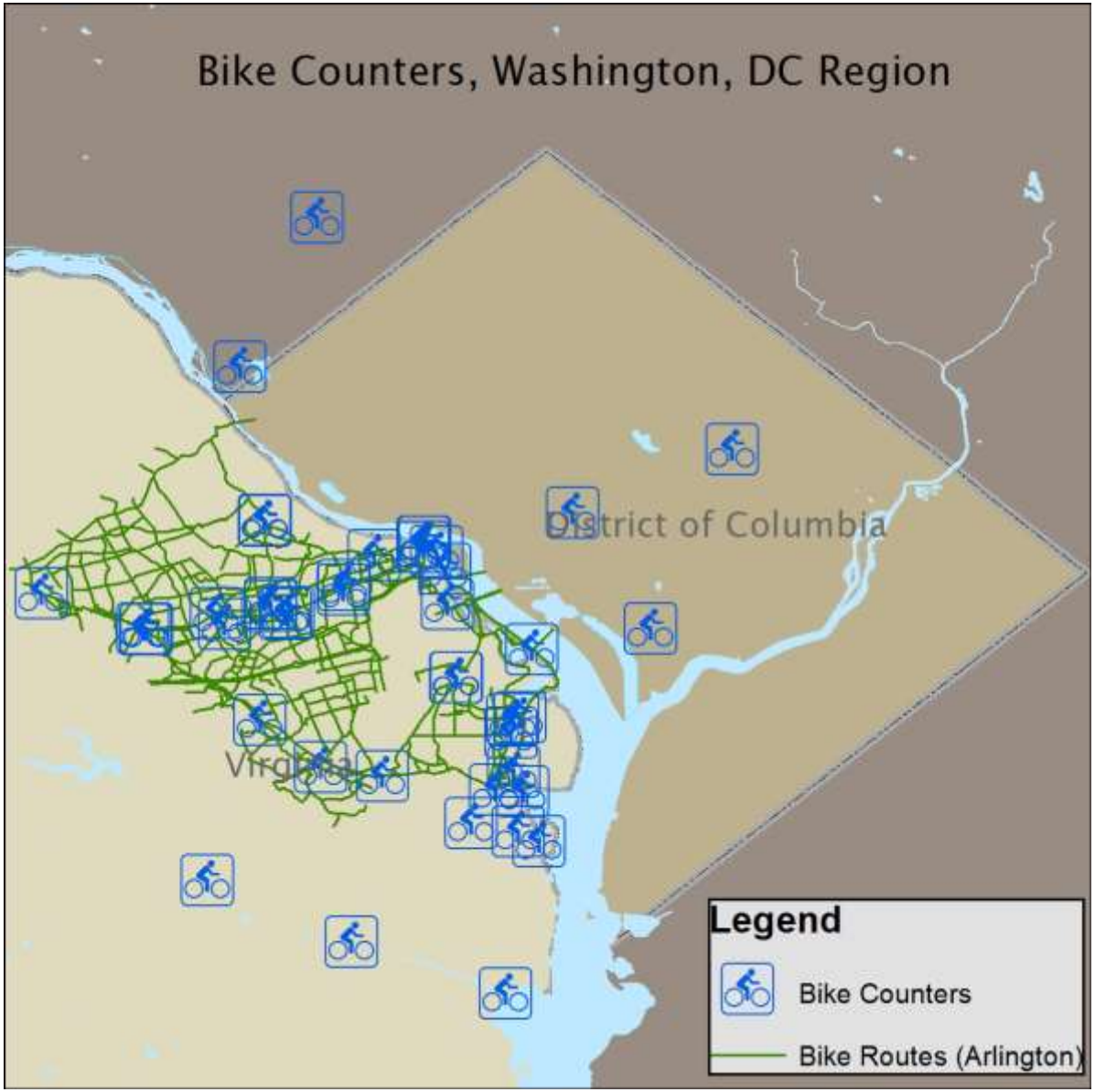


Picture credits: Bikearlington.com and http://www.eco-compteur.com/en/products/zelt-range/urban-zelt

Context: Bike Commuting and Bike Count Sensors

Washington, DC Region

- Tops nation in traffic congestion*
- Small but growing cadre of bike commuters**
  - 2010: **5.0%**
  - 2011: **5.41%**
  - 2012: **6.22%**
  - 2013: **6.91%**
  - 2014: **7.39%**
  - 2015: **7.87%**
- Growing Network of Bike Trails
- Increasing use of Sensors
- Bike trail usage data provided by regional partners (API)
- **But how to make sense of all the data generated by these sensors?**
- **Build on prior research:**
  - Weekend vs. weekday patterns (Jake VanderPlas, Seattle)
  - Commuter vs. Recreational Counters (Fraser McLaughlin, Eco-Counter)



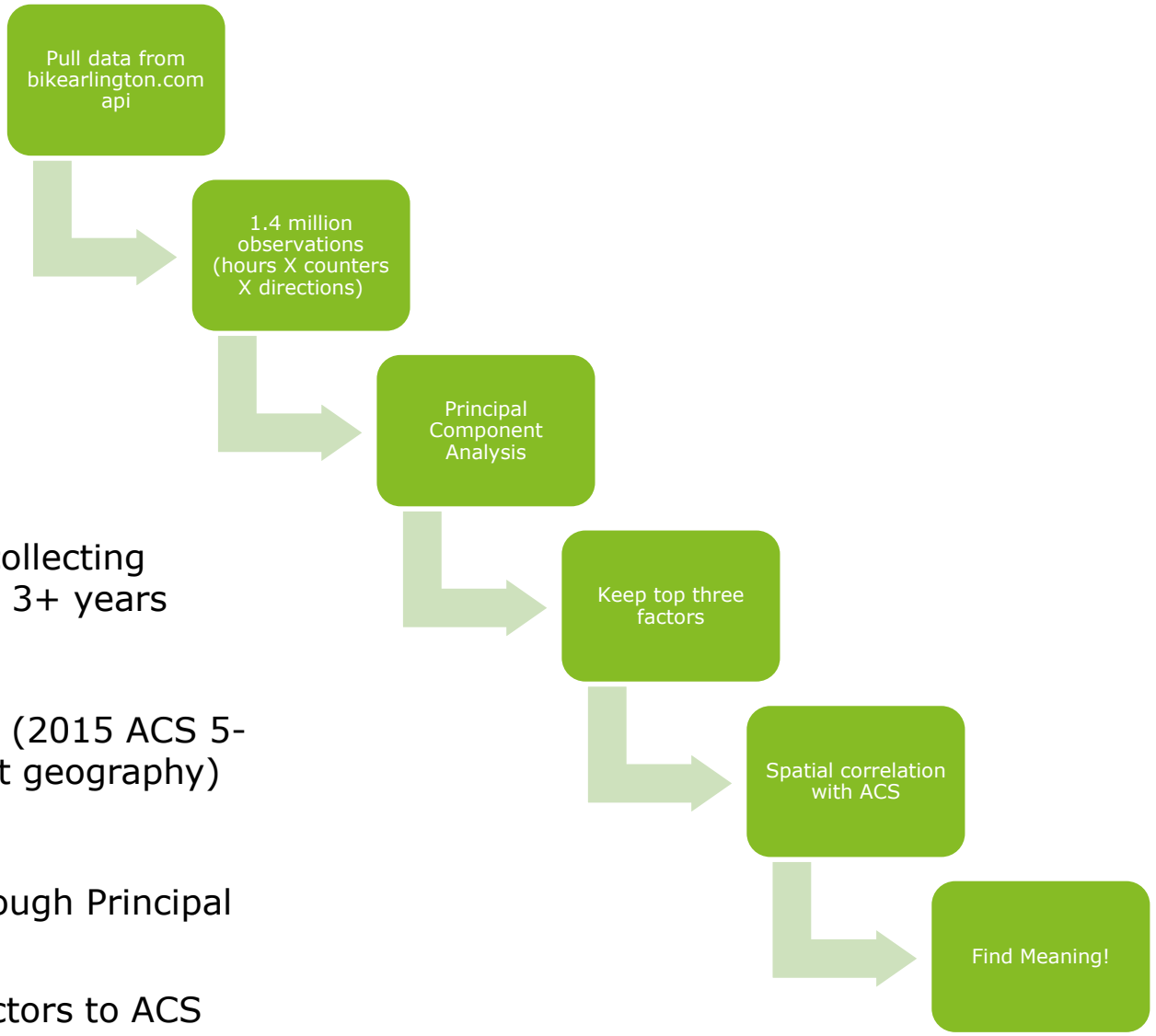
Sources:

** Texas Transportation Institute Urban Mobility Scorecard*

***ACS 5-year estimates, B08301 Means of Transportation to Work, DC MSA*

Data and Methods

Overview



Data

- Bike counters: 45 sensors collecting observations every hour for 3+ years
- (34,265 counter X days)
- ACS Demographic variables (2015 ACS 5-year estimates, census tract geography)

Methods

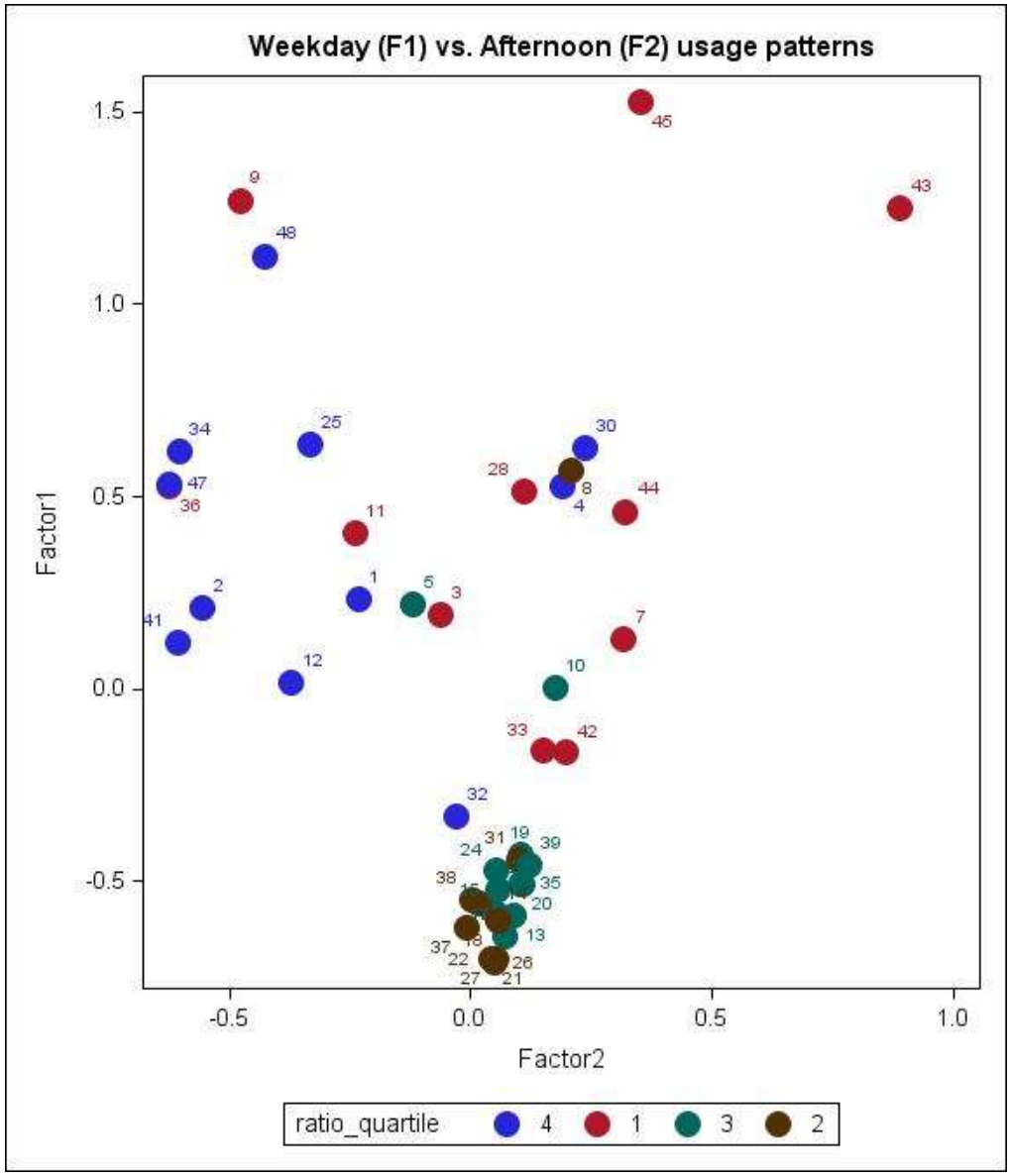
- Dimensionality reduction through Principal Component Analysis (PCA)
- Spatial Correlation of PCA factors to ACS variables

Methods Part 1: Dimensionality Reduction of Sensor Data

Principal Component Analysis and Visualization

Follow method of VandenPlas for [Seattle biking patterns]:

- Convert each sensor-day to a 24-dimensional vector, 1 dim per hour
- Principal Component analysis reveals 3 significant factors explain
  - Factor 1: Weekday commuting usage pattern
  - Factor 2: Recreational (afternoon) usage
  - Factor 3: High late-night (night shift?) usage
  - Factor 4: 3-6 AM peak
- Visualize sensors in factor1 X factor2 space



Methods Part 2: Spatial overlay of sensors with ACS data

ACS data selection: 2015 5-year census tract data for:

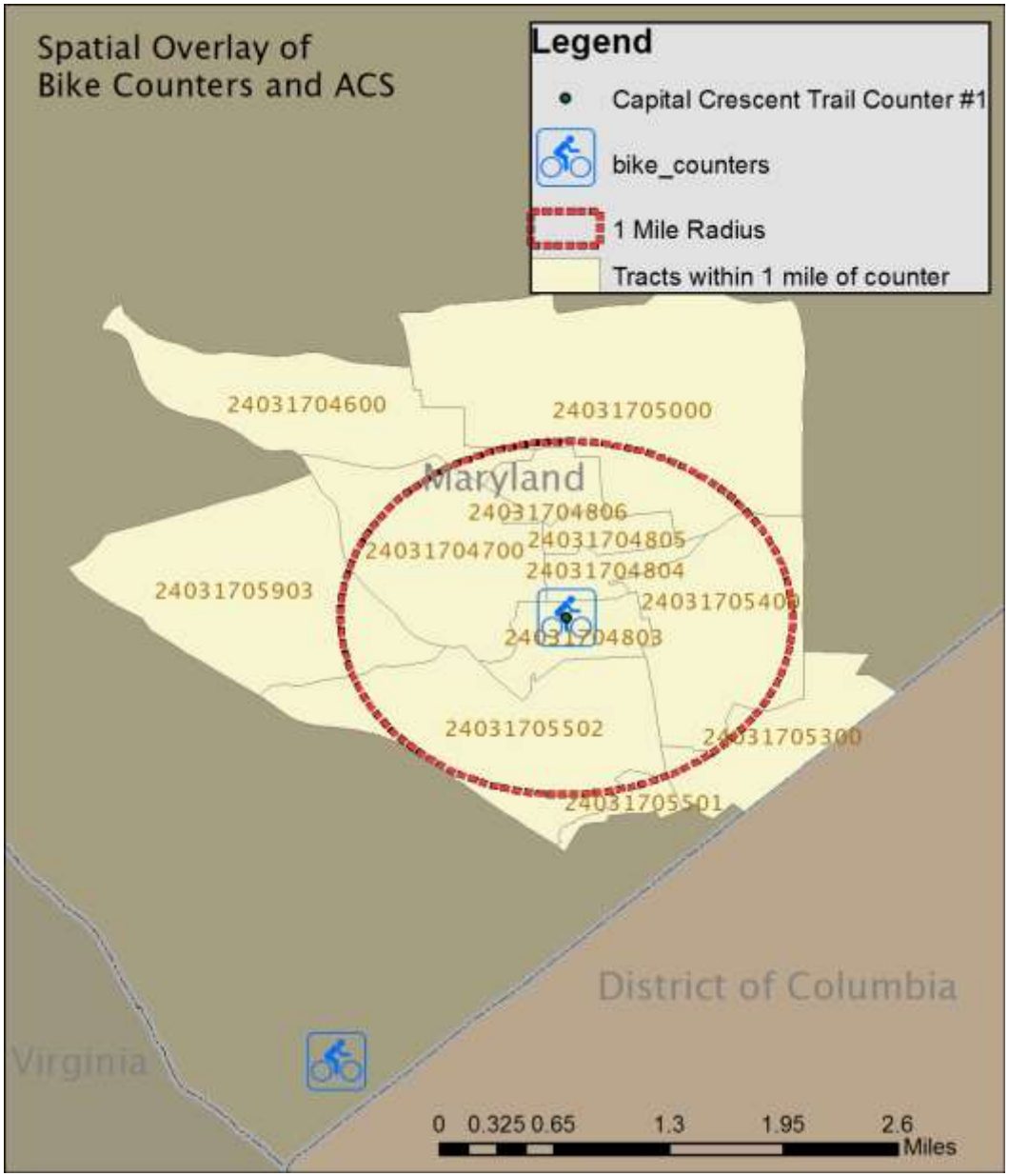
- Bike commuter modal share
- Commute characteristics
- Vehicle ownership
- Household size
- Age
- Education level
- income

Select tracts within 1-mile radius of counter

Average ACS variables over list of tracts for each sensor

Calculate Pearson product-moment correlations between 3 PCA factors and ACS averages

Sample Spatial Correlation with Bike Sensor PCA Factors



Methods Part 3: Analysis and Results

Identify significant* correlates

Commuter Segment correlates with:

- Areas with high bike commute share and transit use
- Areas with fewer vehicles

Recreational User Segment correlates with:

- Transit use
- Longer commutes
- Younger residents
- Smaller households

Late-night User Segment correlates with:

- Younger residents
- Smaller households
- Lower incomes
- Longer commutes

ACS Correlate	Factor 1: Commuters	Factor 2: Recreational	Factor 3: Late Night
Biking Share	+		
Transit Share	+	+	
Vehicles Available	-		
Travel Time to Work		+	+
Median Age		-	-
HH Size		-	-
High Income Share			-
Work in County Share		-	

**Correlations significant at the level of $p < .05$*

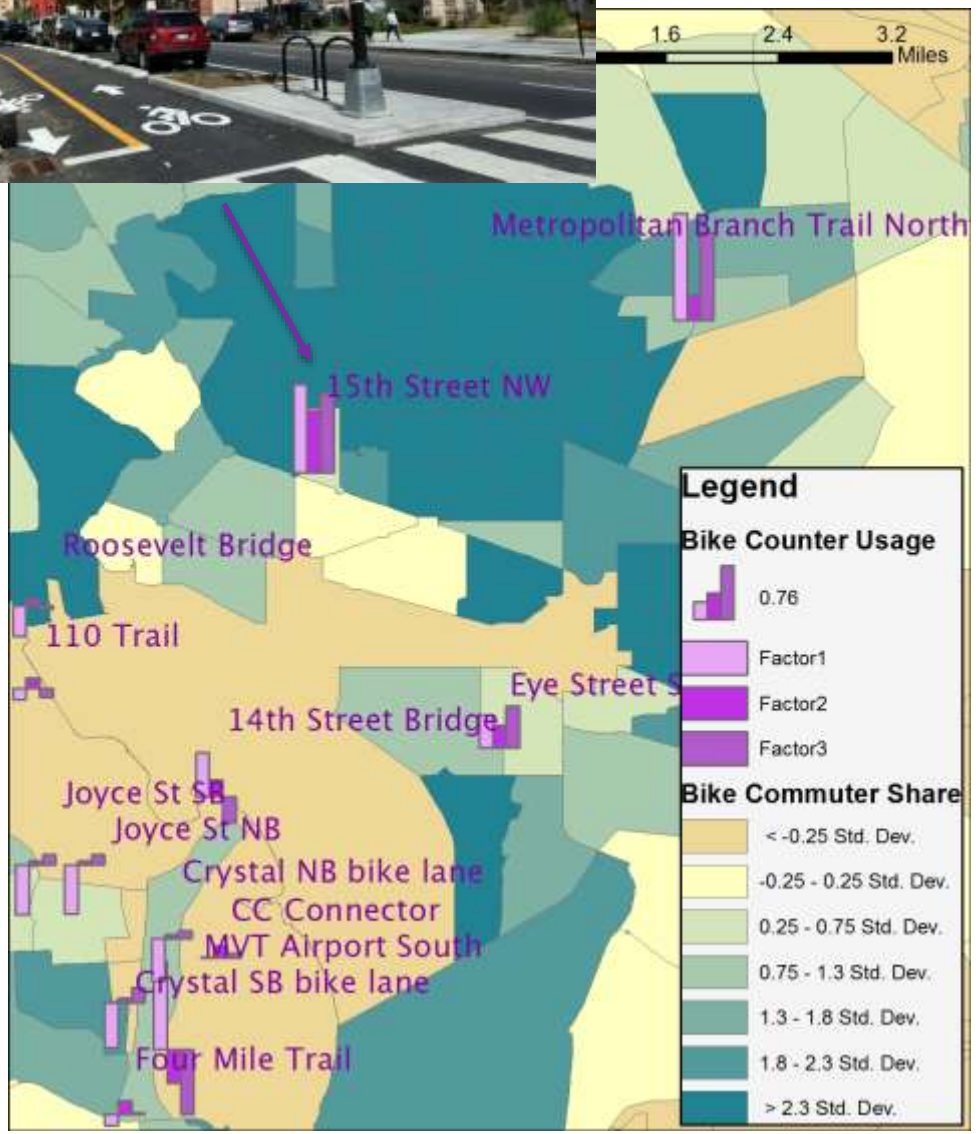
Discussion:
Results and Future Research

Generalizable Uses:

- Make outlier detection of sensors more robust
- Predict usage patterns of points on trails
- Improve trail signage and lighting based on 3 user segments

Future research:

- Refine spatial correlation methods
- Rationalize choice of buffer distance
- Weight demographic variable averages using distance decay
- Use CTPP origin-destination data in addition to ACS
- Extend analysis to more complex traffic flows



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Questions?