Monitoring and Modeling Urban Trail Traffic

May 3, 2016

Research Objectives

1. Estimate annual average daily trail traffic for urban trail networks in Minneapolis MN and Columbus OH

2. Estimate direct (facility) demand models for trail segments in each network

3. Validate and cross-validate direct demand models

Research Findings

1. FHWA Traffic Monitoring Guide procedures work well for monitoring urban trail traffic

2. Direct demand models fit moderately well; explain much of variation in trail AADT

3. Models perform poorly in cross-validation experiments

FHWA Traffic Monitoring Guide

- Objective: two key performance measures
  - Average annual daily traffic (AADT)
  - Vehicle miles traveled (VMT)

- Approach
  - Establish network of permanent and short-duration monitoring sites
  - Use adjustment factors from reference sites to extrapolate short-duration counts

- Challenges in Nonmotorized Monitoring
 - Traffic variability, technology, resources

Characteristics of Columbus and Minneapolis Networks

	Minneapolis	Columbus (city)	Columbus (metro, including city)
Trail miles	80	51	110
Reference monitoring sites	6	5	6
Short-duration monitoring sites	80	36	61
Total different monitoring locations	86	41	67
Mean segment length (mile)	0.93	1.25	1.59
Monitoring technology	TrailMaster © active infrared	TRAFx © passive infrared, TrailMaster © active infrared	
Monitoring periods (sampling)	2013	2014	2014

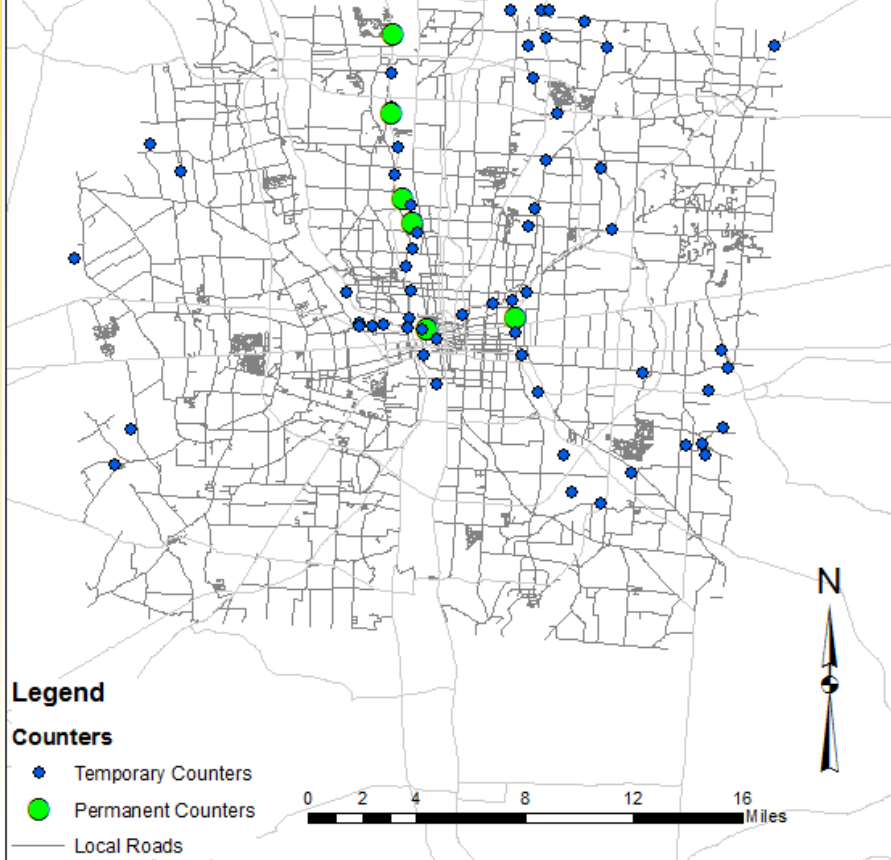# MSP Short Duration Monitoring Plan
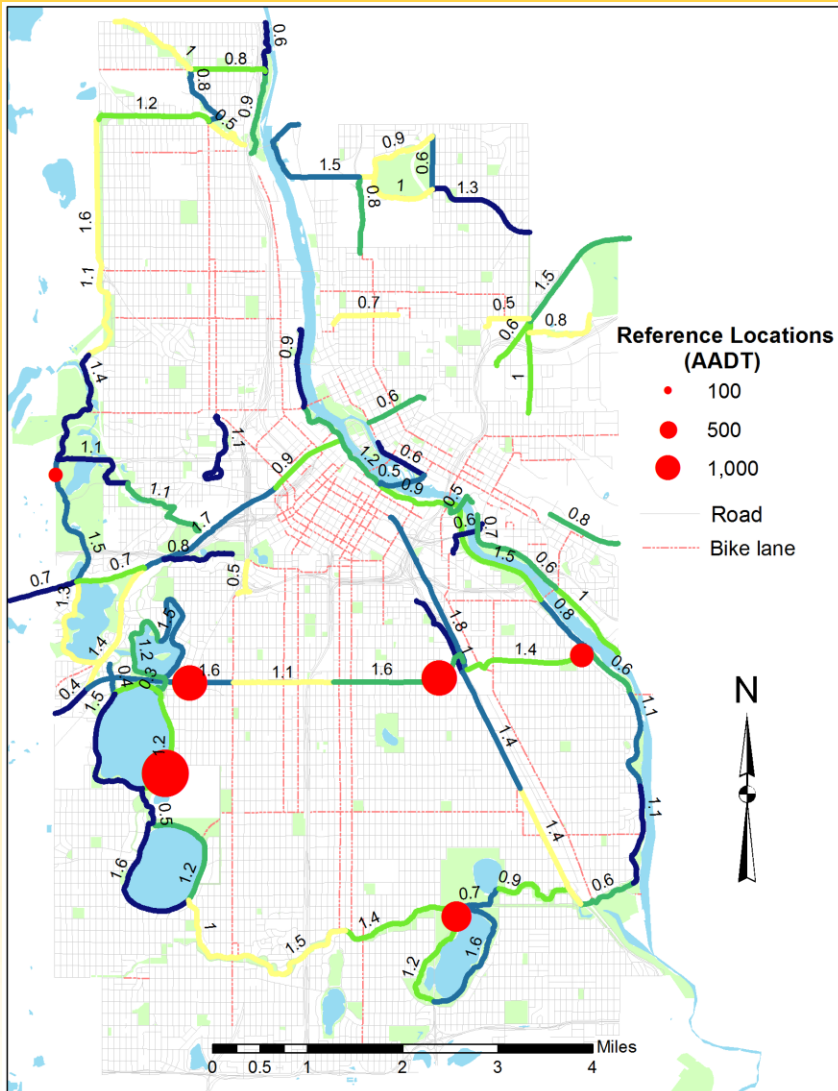
No. of segments = 82
Sum = ~80 miles
Mean = 0.98 miles
Min = 0.17 miles
Max = 1.8 miles
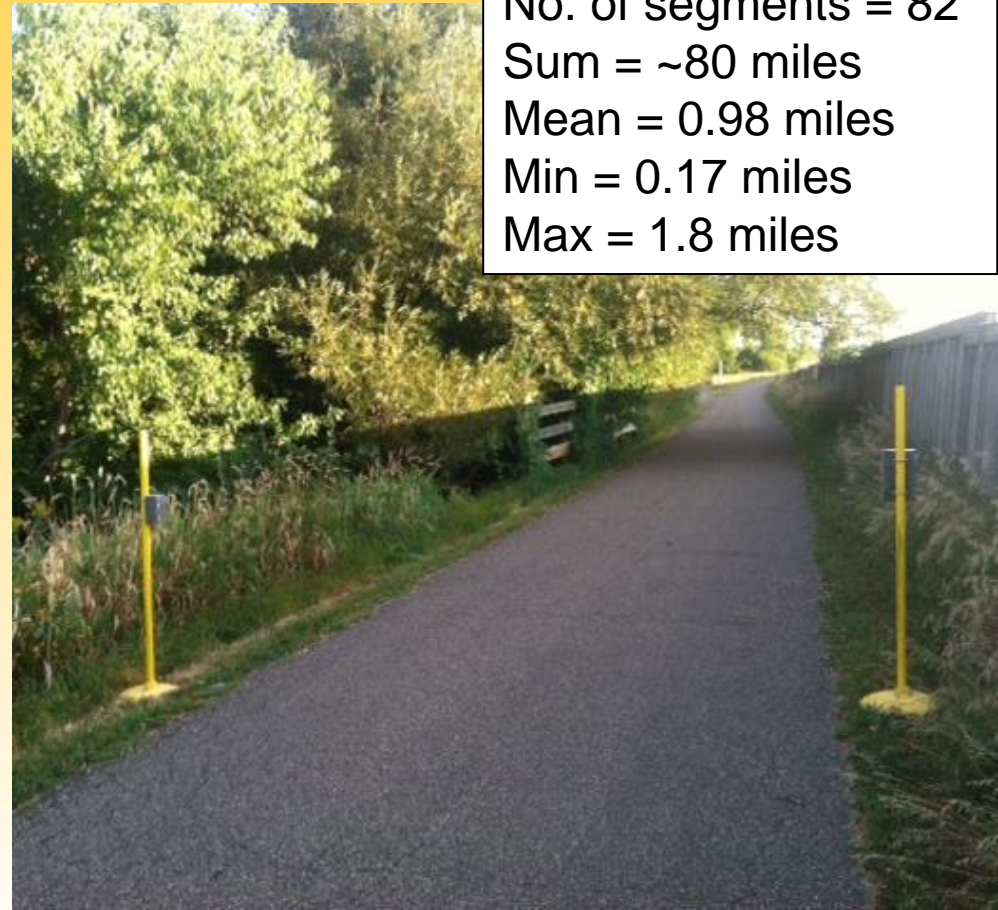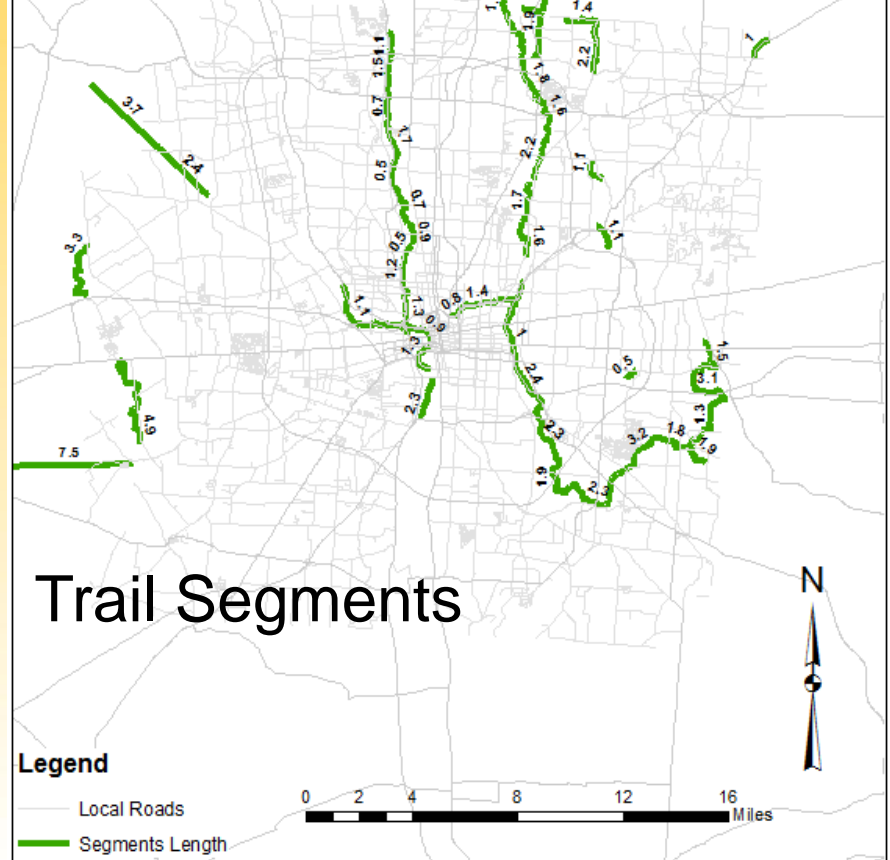
Columbus Short Duration Monitoring Plan

Descriptive Statistics

No. of Counters = 67
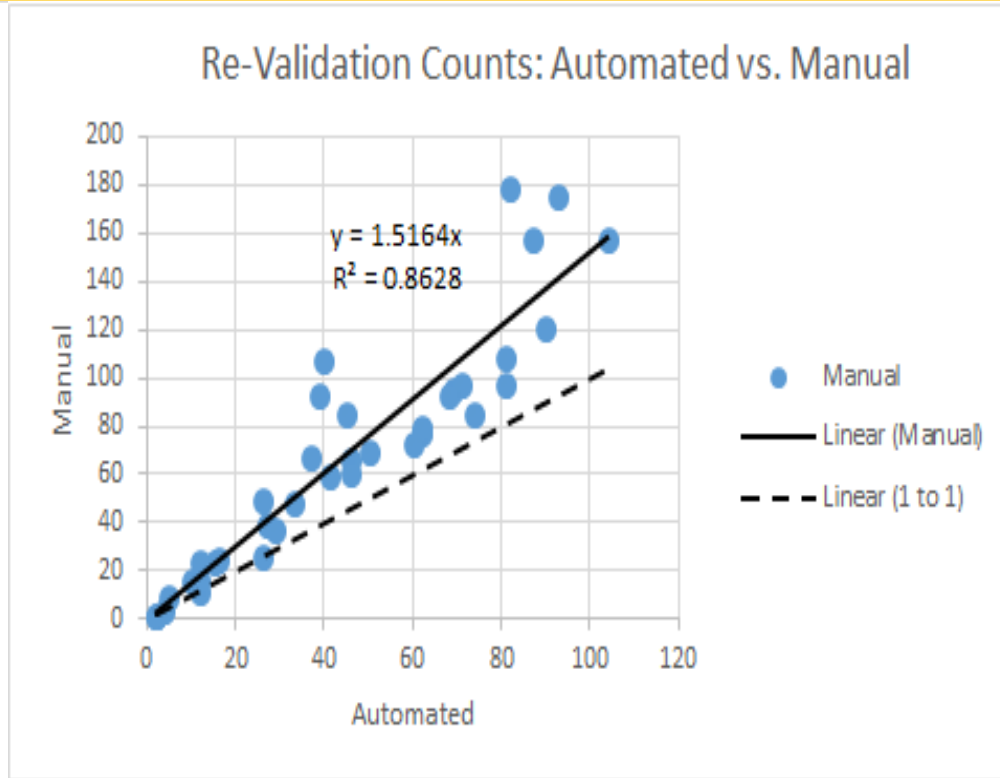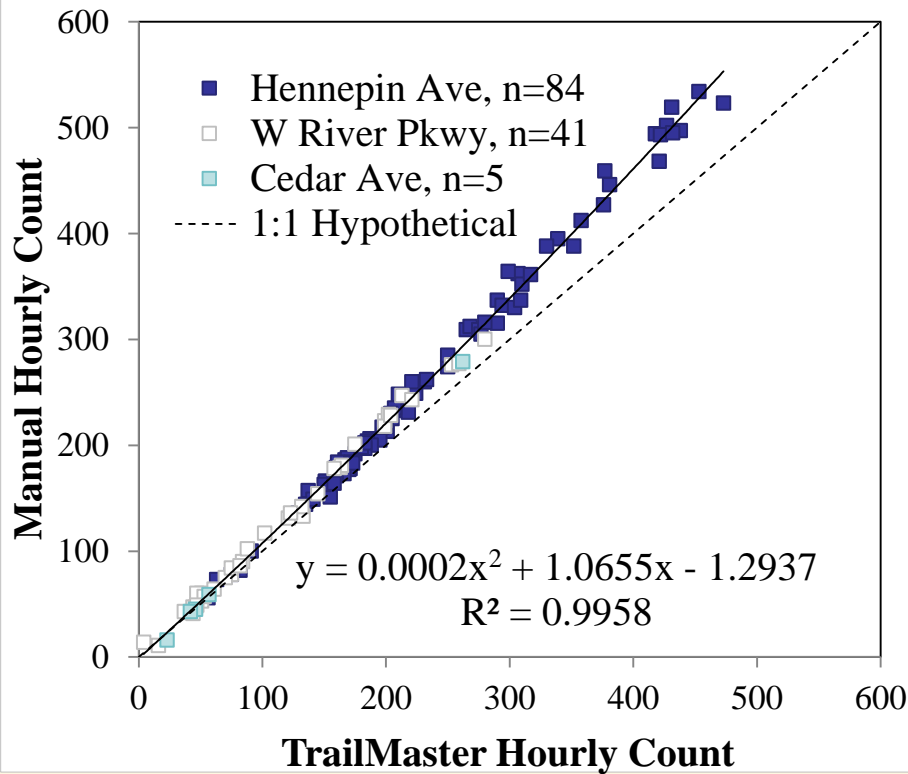Temporary Counters = 61
Permanent Counters = 6

Legend

Counters

- Temporary Counters
- Permanent Counters
- Local Roads

Trail Segments

Descriptive Statistics

No. of Segments = 67
Sum Length = 110.8 miles
Mean = 1.6 miles
Minimum = 0.2 miles
Maximum = 7.5 miles

Legend

- Local Roads
- Segments Length

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Adjusting for Systematic Counter Error

Minneapolis

Columbus

Minneapolis MN and Columbus OH Trail Segments: Estimates of AADT

	Minneapolis	Columbus City	Columbus Metro
Maximum AADT	3754	1256	1403
Mean AADT	1022	355	330
Median AADT	848	204	217
Minimum AADT	39	20	13

Minneapolis   Columbus

Trail AADT
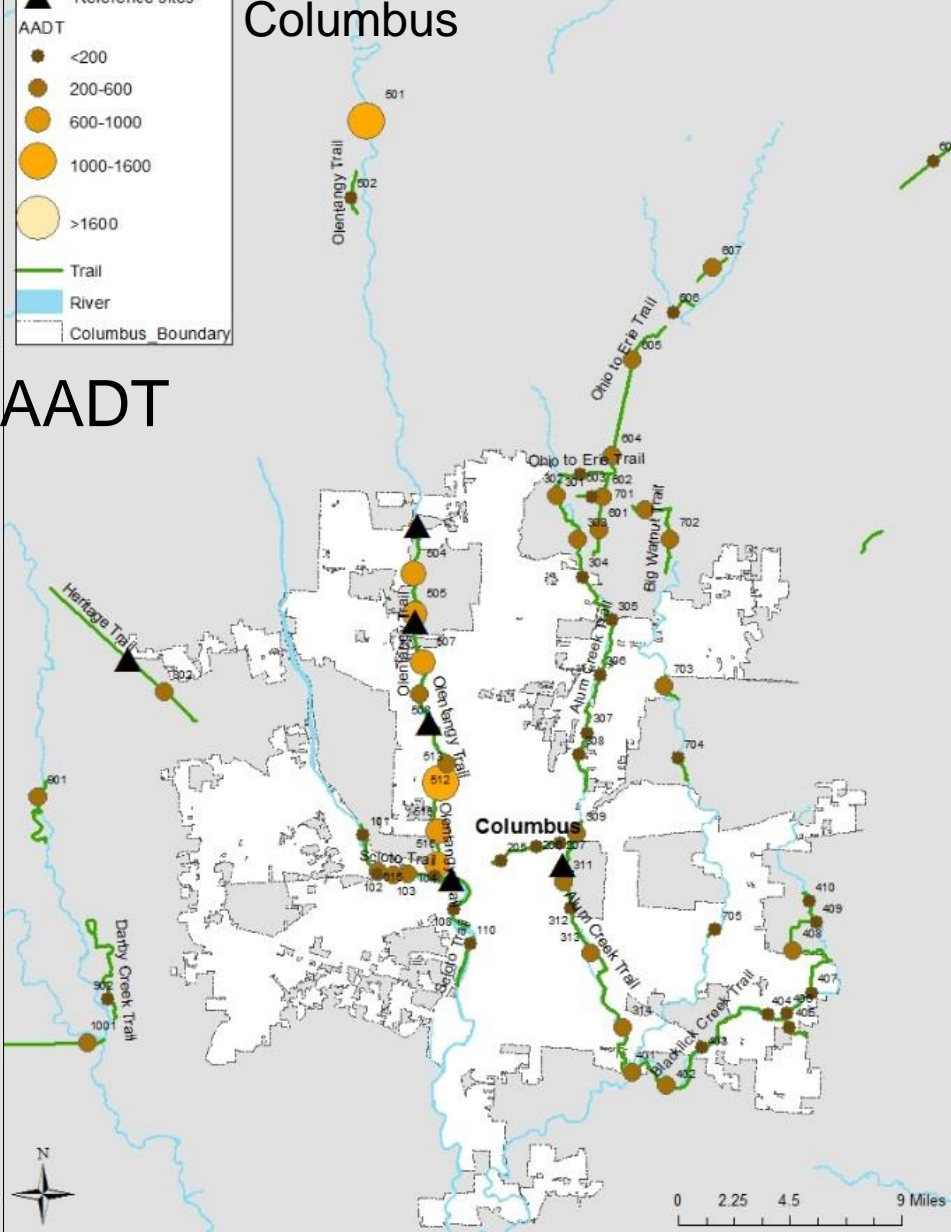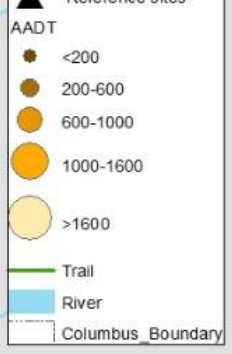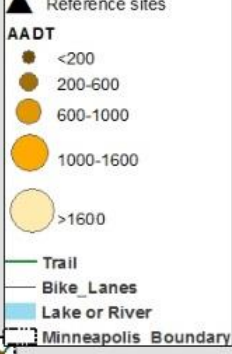
AADT and Trail Miles Traveled in Minneapolis
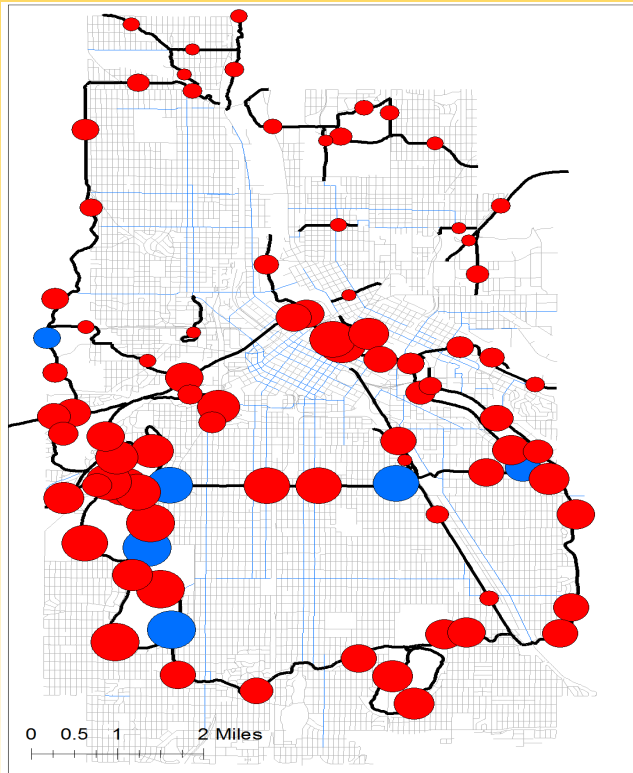
Estimated AADT
- 1st Quartile (0 - 127)
- 2nd Quartile (127 - 662)
- 3rd Quartile (662 - 1,196)
- 4th Quartile (1,196 - 3,522)

Segment	AADT
Mean	954
Median	750
Max	3,728
Min	39

- 6 reference sites
- 7 day short duration counts on each segment
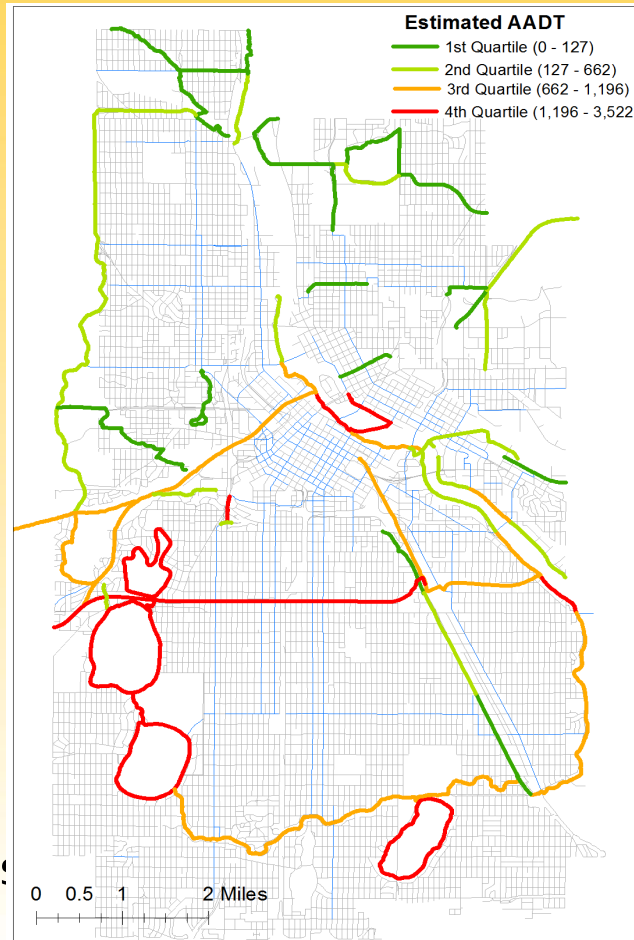
> 28 million miles traveled on 80 mile trail network in 2013:

± 12,000,000 miles traveled in 2014
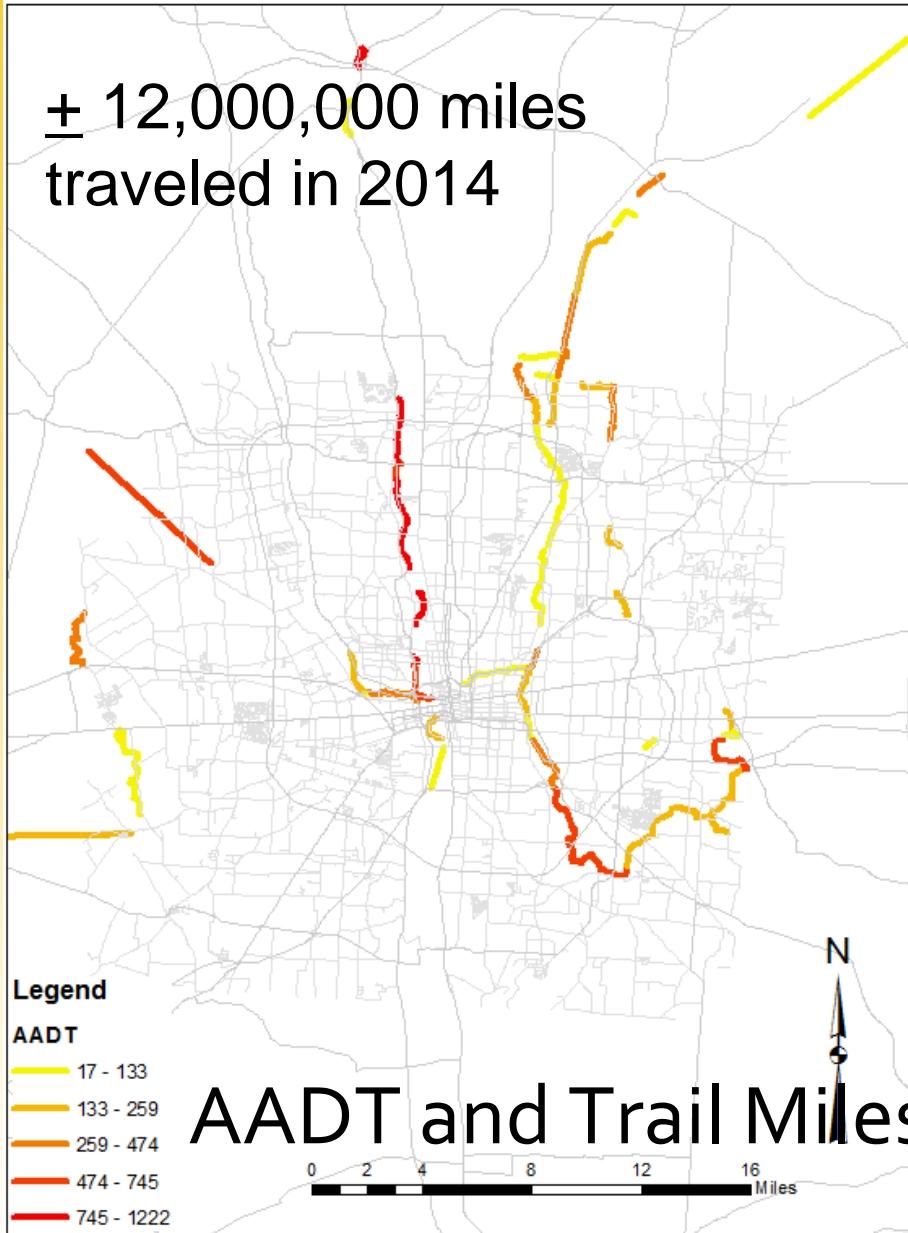
Annual Average Daily Trail Traffic
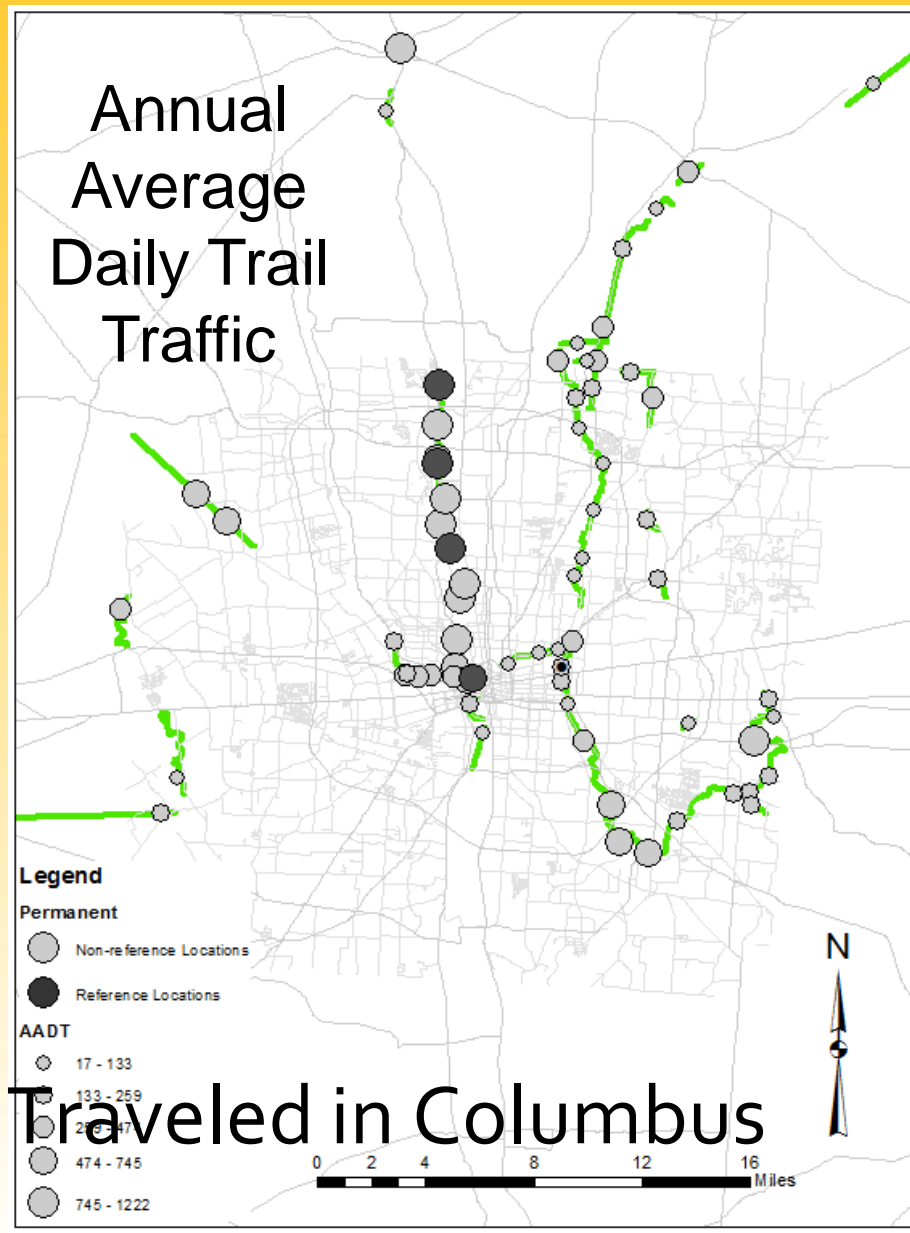
AADT and Trail Miles Traveled in Columbus

Legend

AADT
- 17 - 133
- 133 - 259
- 259 - 474
- 474 - 745
- 745 - 1222

N

0 2 4 8 12 16
Miles

Legend

Permanent
- Non-reference Locations
- Reference Locations

AADT
- 17 - 133
- 133 - 259
- 259 - 474
- 474 - 745
- 745 - 1222

N

0 2 4 8 12 16
Miles

Facility Demand Models (NCHRP 770)

- Require counts or other measures as inputs
- Useful for planning, understanding system
- Do not explain causation
- Have limitations
  - Need to include variables of interest
  - Need to be calibrated
  - Need to be validated
  - Should not be not transferred
- Can be strengthened
  - Potential to cross-validate with choice models

Direct Demand Models from Counts

- Trail traffic volume function of:
  - neighborhood socio-demographics
  - built environment (e.g., land use, jobs)
  - transportation infrastructure
  - weather
  - access to recreation (e.g., lakes)
- Modeling approach
  - Same variables
  - Use nationally available data sets (Census, USEPA Smart Growth Database)
  - Minneapolis, Columbus (city, region), Two-city model

Minneapolis and Columbus Trail Demand Models

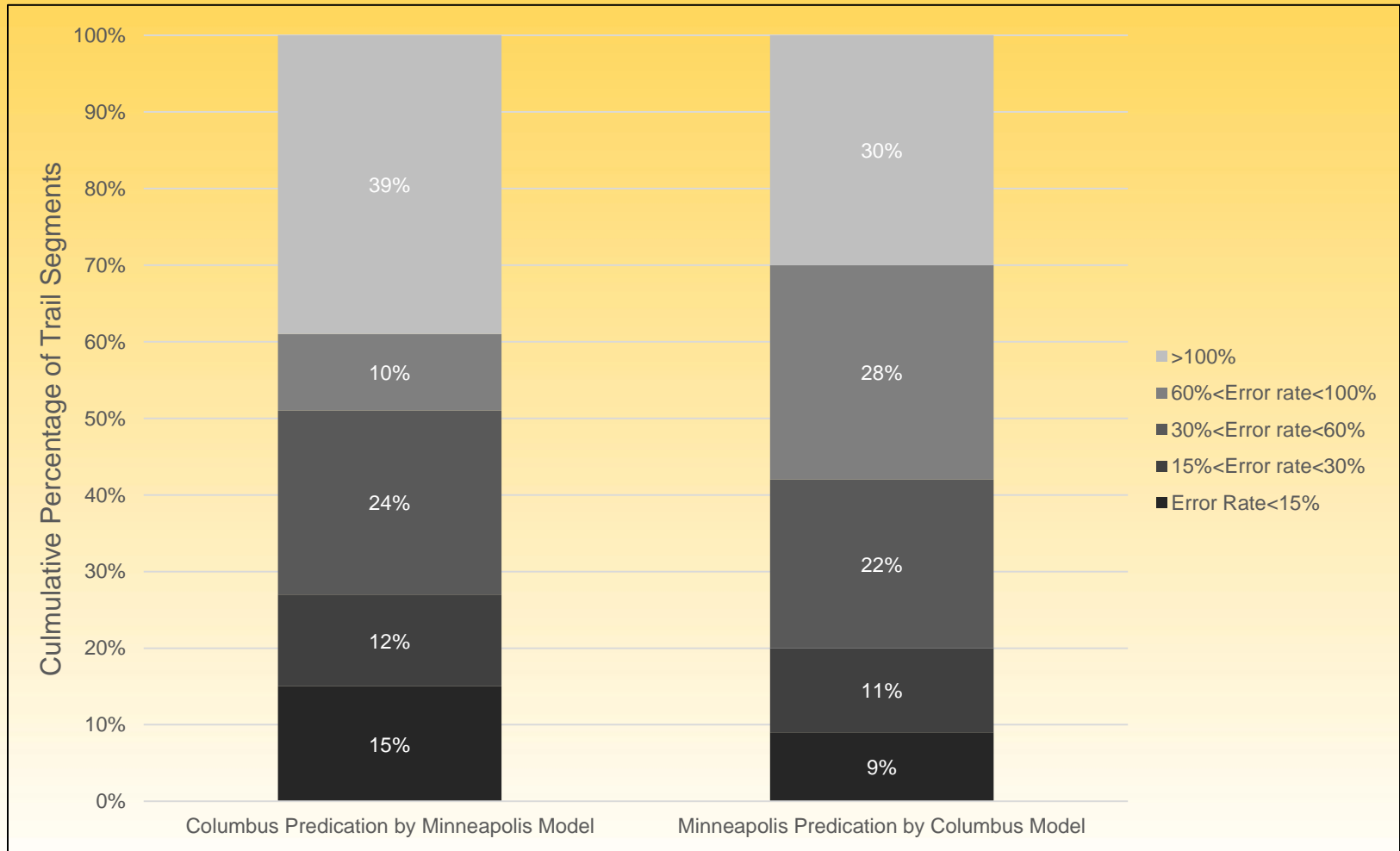| Variable	Minneapolis	Columbus	Columbus Region	Two Cities
Socioeconomic				
Pct young/old				
Pct_black	√	√	√	√
Pct_Others	√			
Med income HH (1000)				
Built Environment				
Population density	√	√		√
Land use diversity	√			√
Net Den_Ped				
Int Den_Auto				
Pct_ind				
JA_Walk(1000)				
Trail Location Characteristics (Dummy)				
Disconnect	√		√	√
Lake	√	na		√
Cnox_Snell R²	0.64	0.576	0.318	0.609

√**: Significant at the level of $p < 0.1$

Within-City Validation Prediction Error (Trail AADT)
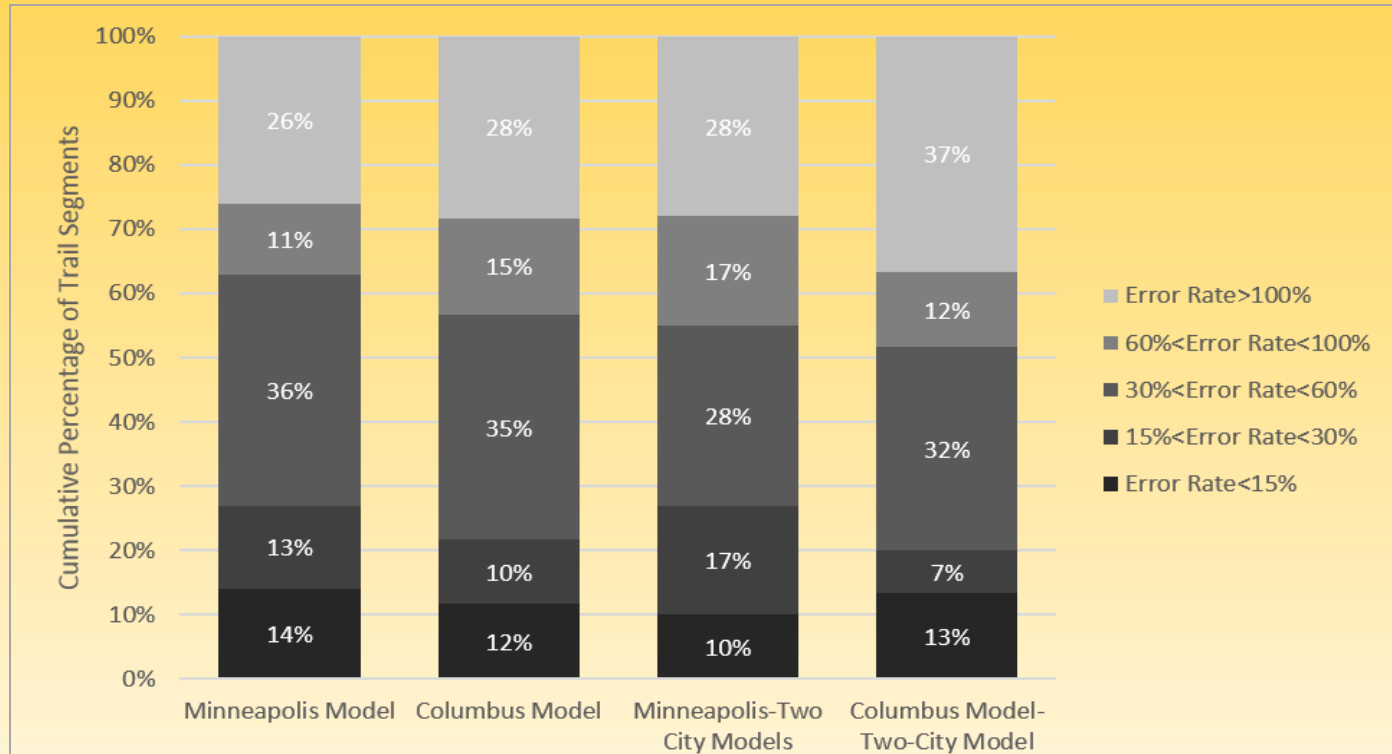
	Minneapolis Model	Columbus Model	Two-City Model	
			Minneapolis	Columbus
Average Error all predication	132%	137%	143%	185%
Average Total Error	26%	25%	19%	25%

Cross-City Validation Prediction Error (Trail AADT)

Cumulative Percentage of Trail Segments

Columbus Predication by Minneapolis Model
- 15%
- 12%
- 24%
- 10%
- 39%

Minneapolis Predication by Columbus Model
- 9%
- 11%
- 22%
- 28%
- 30%

Legend:
- >100%
- 60%<Error rate<100%
- 30%<Error rate<60%
- 15%<Error rate<30%
- Error Rate<15%

Monitoring and Modeling Urban Trail Traffic

1. FHWA monitoring procedures can be used to characterize variation in traffic flows on urban trail networks.
2. Direct demand models trail traffic have reasonably good fit, but predicted traffic volumes for > one-third of segments exceed actual volumes by > 60%.
3. Cross-validation results indicate models cannot yet be applied as predictive tools across cities.
4. Experimentation needed to assess the feasibility of developing generalized direct demand models for trails.

Extra Slides

These slides included if questions arise.

FHWA Traffic Monitoring Guide

Permanent Continuous Monitoring	Short Duration Monitoring
1. Review existing continuous count program	1. Select count locations
2. Develop inventory of available continuous count locations and equipment	2. Select type of count (segment vs intersection)
3. Determine the traffic patterns to be monitored	3. Determine duration of counts
4. Establish seasonal pattern groups	4. Determine method of counting (automated vs. manual)
5. Determine number of continuous count locations	5. Determine number of count s
6. Select specific count locations	6. Evaluate counts (QA/QC)
7. Compute adjustment factors	7. Apply factors (occlusion, time of day, day of week, monthly, seasonal)

Minneapolis Reference Locations

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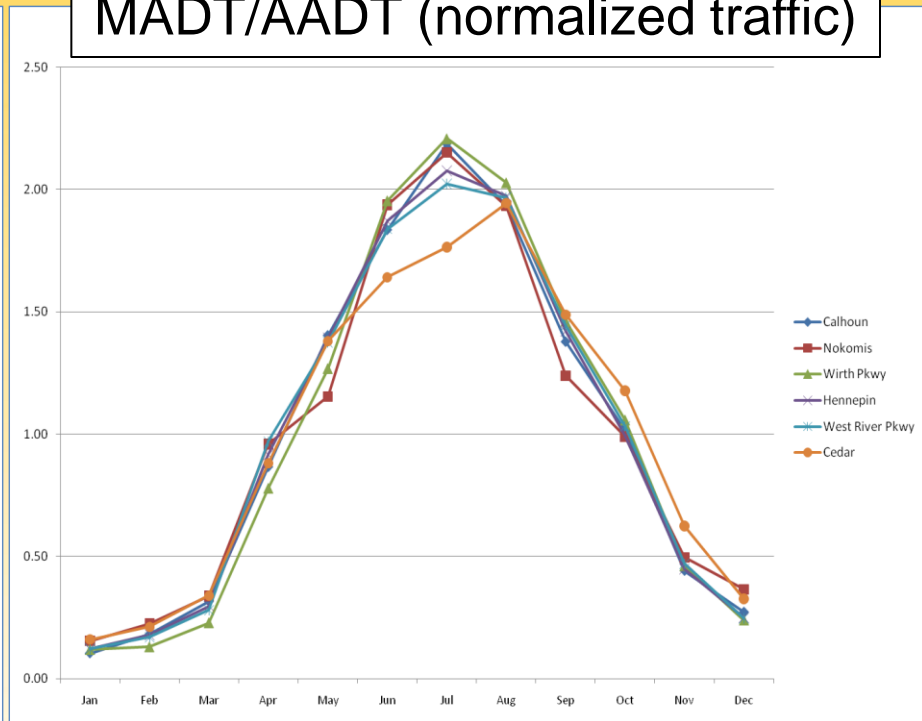
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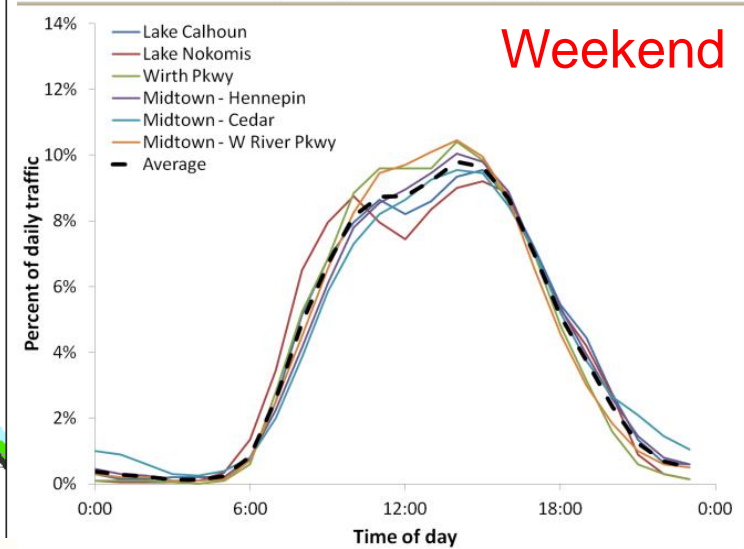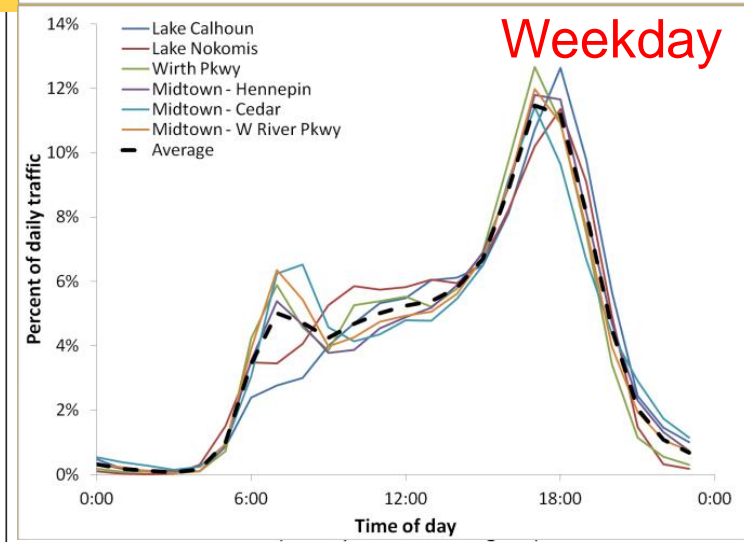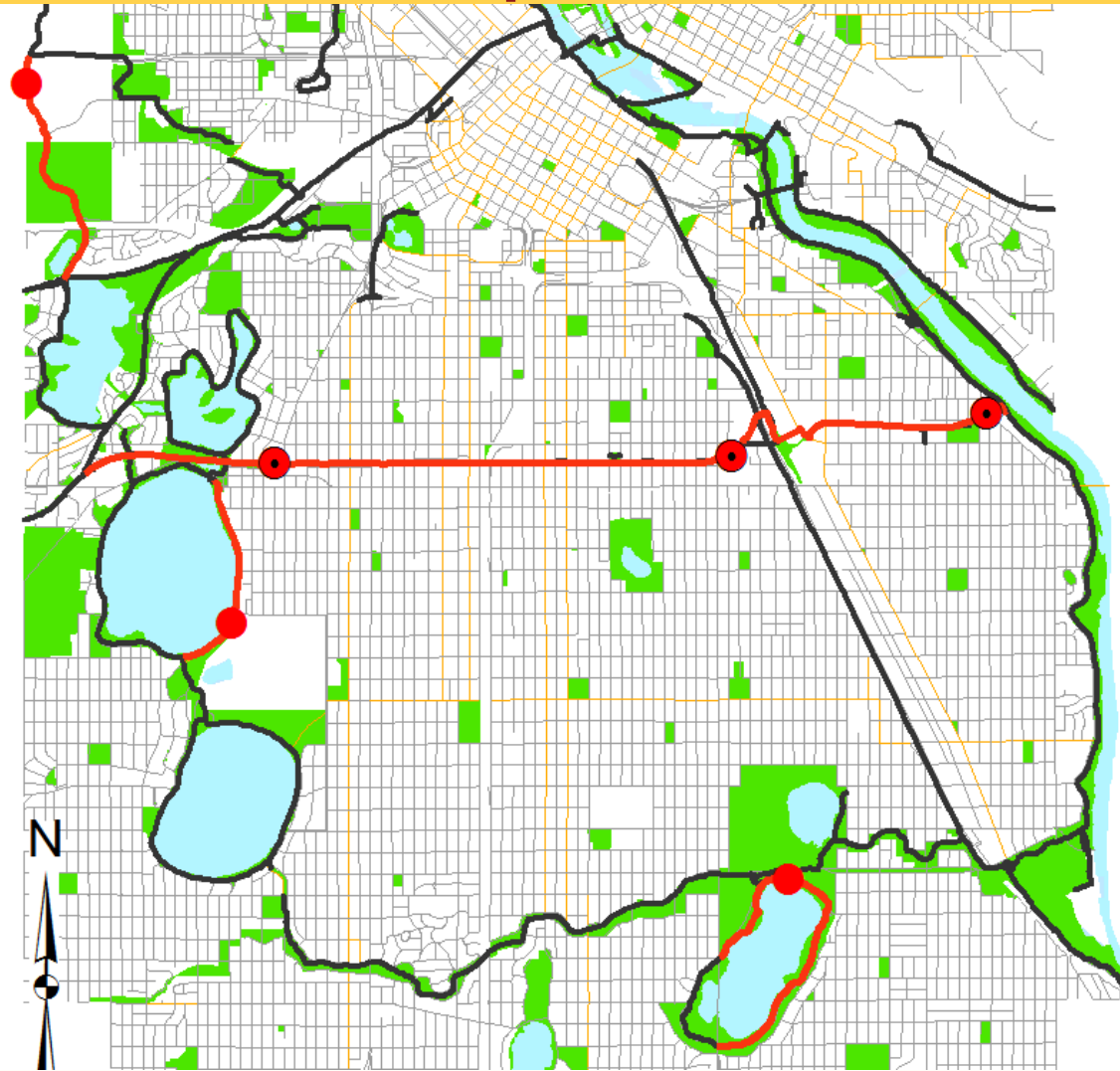
Minneapolis Reference Locations

Monthly Average Daily Traffic (MADT)
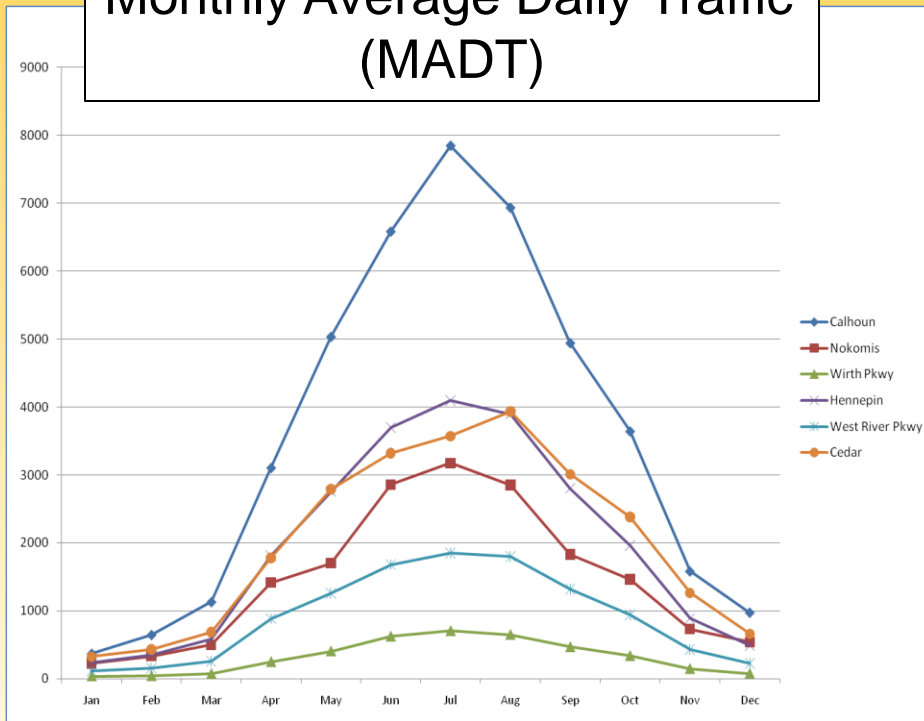
MADT/AADT (normalized traffic)

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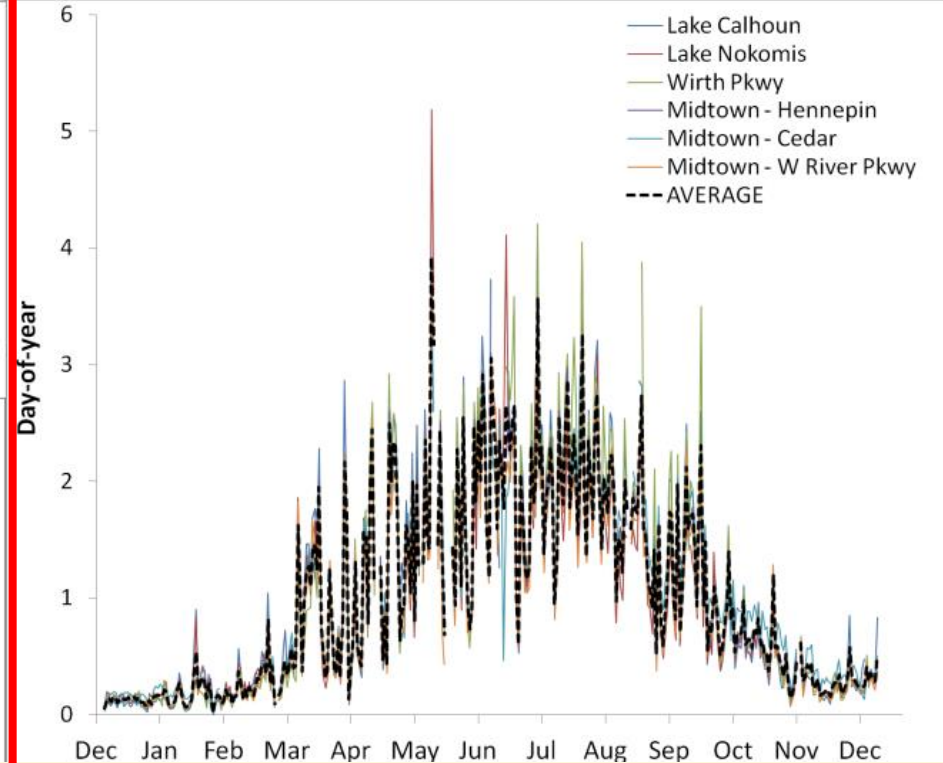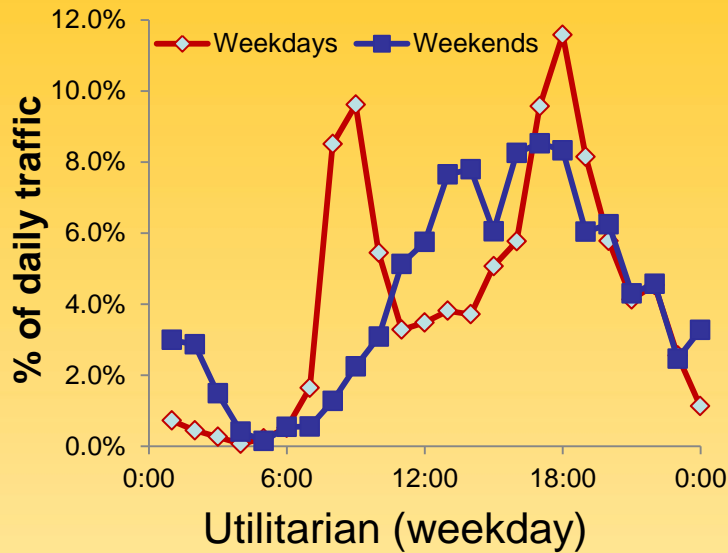**Driven to Discover**
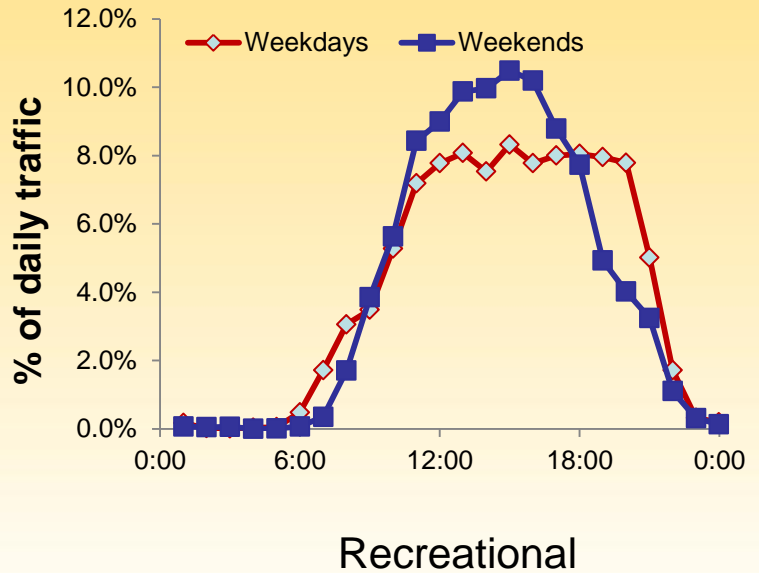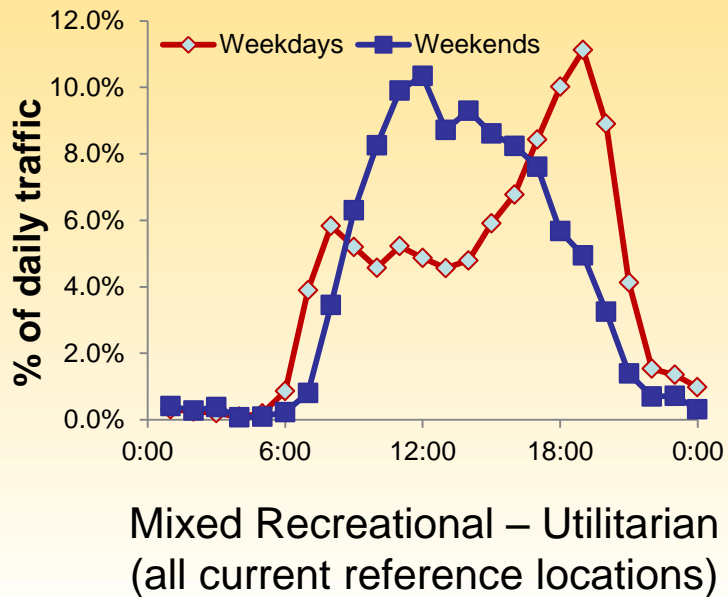
Scaling factors

Approach 1: "Traditional" — Approach 2: "New"
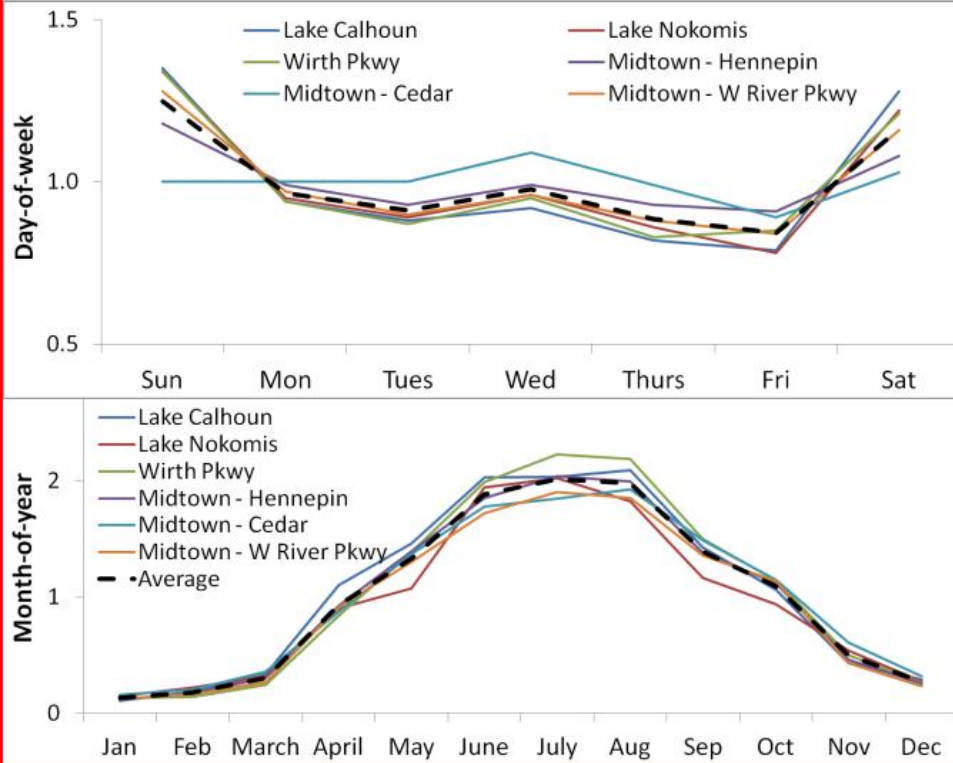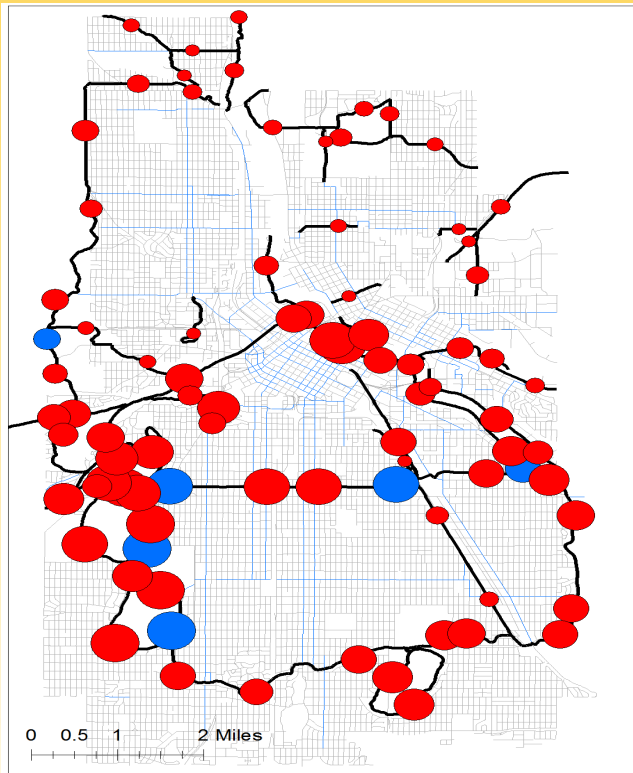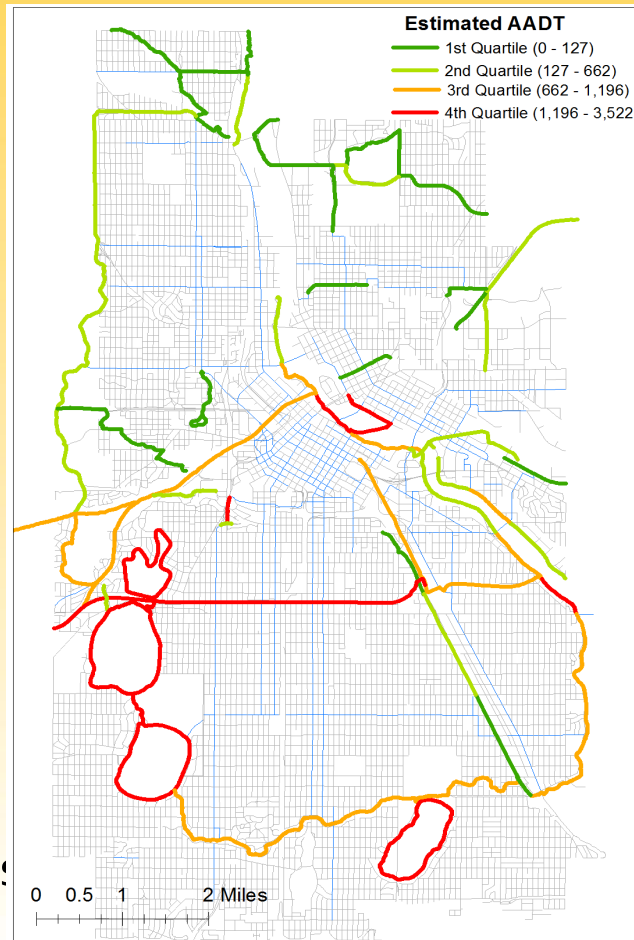
Short-duration monitoring identified three different traffic patterns (factor groups). Need new reference monitoring sites.

Utilitarian (weekday)

Mixed Recreational – Utilitarian
(all current reference locations)

Recreational

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Estimating Performance Measures:
AADT and Trail Miles Traveled in Minneapolis

- 6 reference sites
- 7 day short duration counts on each segment

Estimated AADT
- 1st Quartile (0 - 127)
- 2nd Quartile (127 - 662)
- 3rd Quartile (662 - 1,196)
- 4th Quartile (1,196 - 3,522)

Segment	AADT
Mean	954
Median	750
Max	3,728
Min	39

> 28 million miles traveled on 80 mile trail network in 2013:

Minneapolis and Columbus Trail Demand Models

Variables	Coefficients			
	Minneapolis	**Columbus**	**Columbus Region**	**Two Cities**
Constant	5.51**	5.57**	5.86**	5.82**
Socioeconomic				
Pct_yo	0.48	1.89	-0.38	0.06
Pct_black	-1.49**	-2.25**	-2.28**	-1.54**
Pct_Others	-2.72**	0.88	2.58	-1.36
M_income (1000)	0.0005	-0.0007	-0.003	0.001
Built Environment				
PopDen	0.05**	0.10*	-0.04	0.04**
Diversity	1.05**	-0.31	-0.44	0.52**
NetDen_Ped	0.02	0.03	0.04	0.02
IntDen_Auto	0	0	0.01	0
Pct_ind	-0.36	0.32	-0.16	-0.24
Jobs_byW (1000)	0.004	-0.05	-0.02	0.01
Trail Location Characteristics(Dummy)				
Disconnect	-1.39**	-1.4	-0.48*	-1.40**
Lake	1.08**	na	na	1.18**
Cnox_Snell R^2	0.64	0.576	0.318	0.609

**: Significant at the level of $p < 0.05$; *: significant at the level of $p < 0.1$