

# Performance Measures for Urban Trails

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HUMPHREY SCHOOL  
OF PUBLIC AFFAIRS

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UNIVERSITY OF MINNESOTA  
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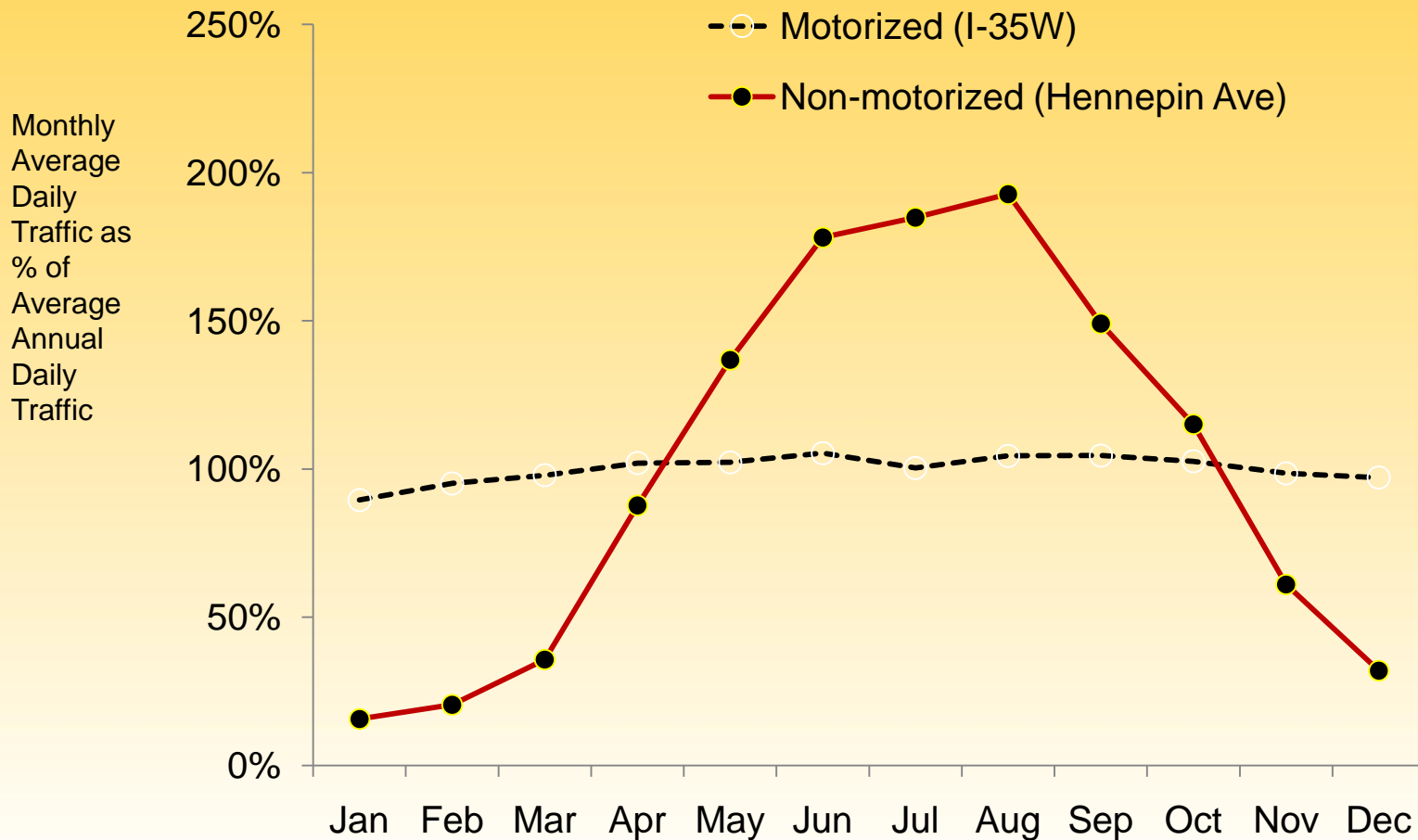
# Performance Measures for Urban Trails

- Motivation
  - *How does traffic vary on our trail network?*
    - » Jennifer Ringold, Manager of Community Engagement and Citywide Planning, Minneapolis Park & Recreation Board
- Approach
  - Adapt procedures for traffic monitoring outlined in Federal Highway Administration *Traffic Monitoring Guide* (2013)

# 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

# Nonmotorized Traffic Varies More Than Motorized Traffic, Harder to Monitor



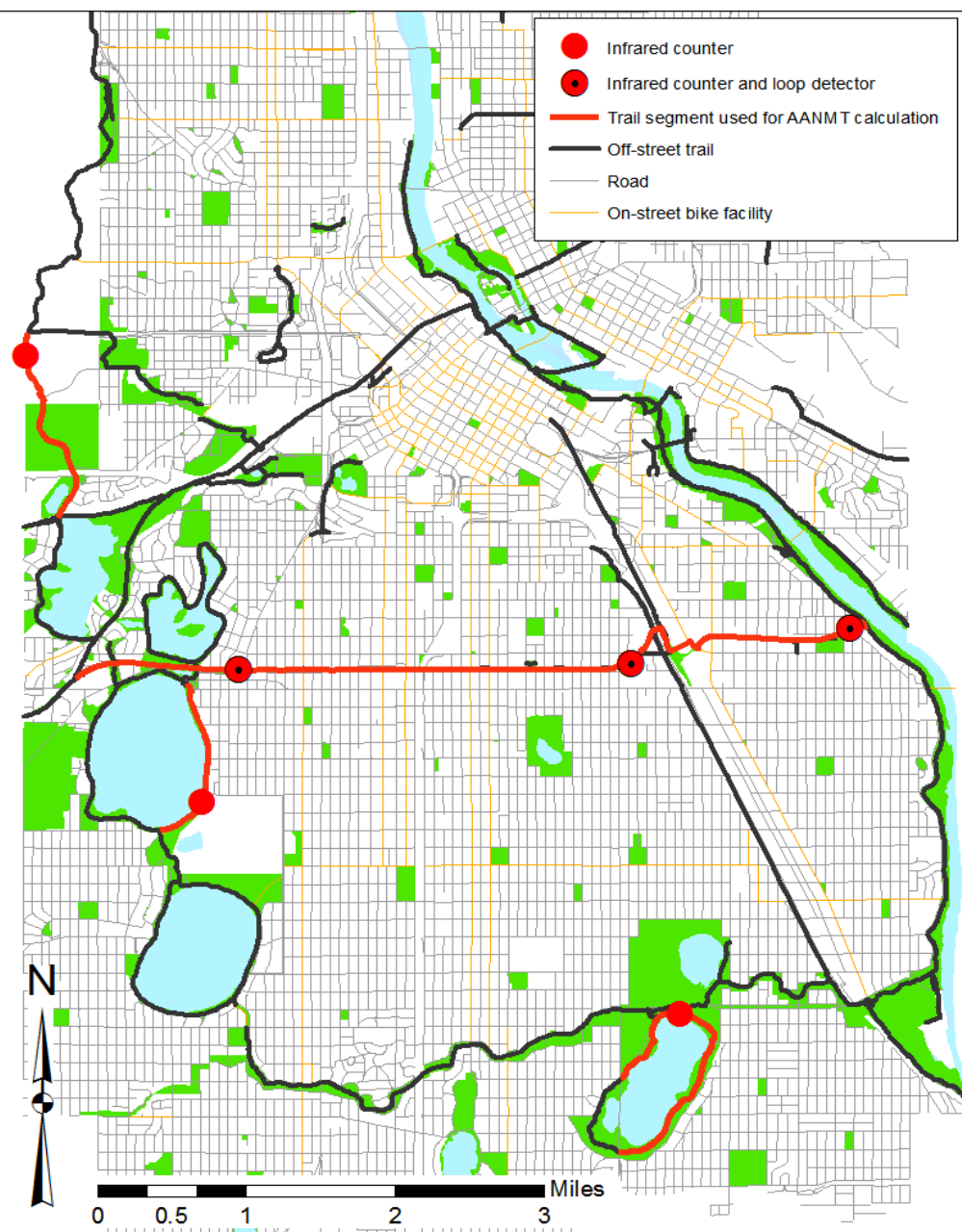
# Trail Monitoring in Minneapolis – Case Study

|                   |  |
|-------------------|--|
| 1. Purpose        | <ul style="list-style-type: none"><li>• Estimates of average annual daily trail traffic, miles traveled (mixed mode = bikes &amp; peds)</li></ul>                    |
| 2. Locations      | <ul style="list-style-type: none"><li>• 6 reference sites, 76 short-duration locations</li></ul>   |
| 3. Technologies   | <ul style="list-style-type: none"><li>• Trail Master Active Infrared Counters (&amp; inductive loops)</li></ul>  |
| 4. QA/QC          | <ul style="list-style-type: none"><li>• On-site calibration, outliers and bad data, correction for occlusion, systematic error</li></ul>                             |
| 5. Analytics      | <ul style="list-style-type: none"><li>• Two-step factoring vs. new day-of-year factors (out of sample validation), estimate AADTT and trail miles traveled</li></ul> |
| 6. Modeling       | <ul style="list-style-type: none"><li>• Negative binomial land use regression, weather controls</li></ul>  |
| 7. Sustainability | <ul style="list-style-type: none"><li>• Collaboration, scrambling for \$</li></ul>   |

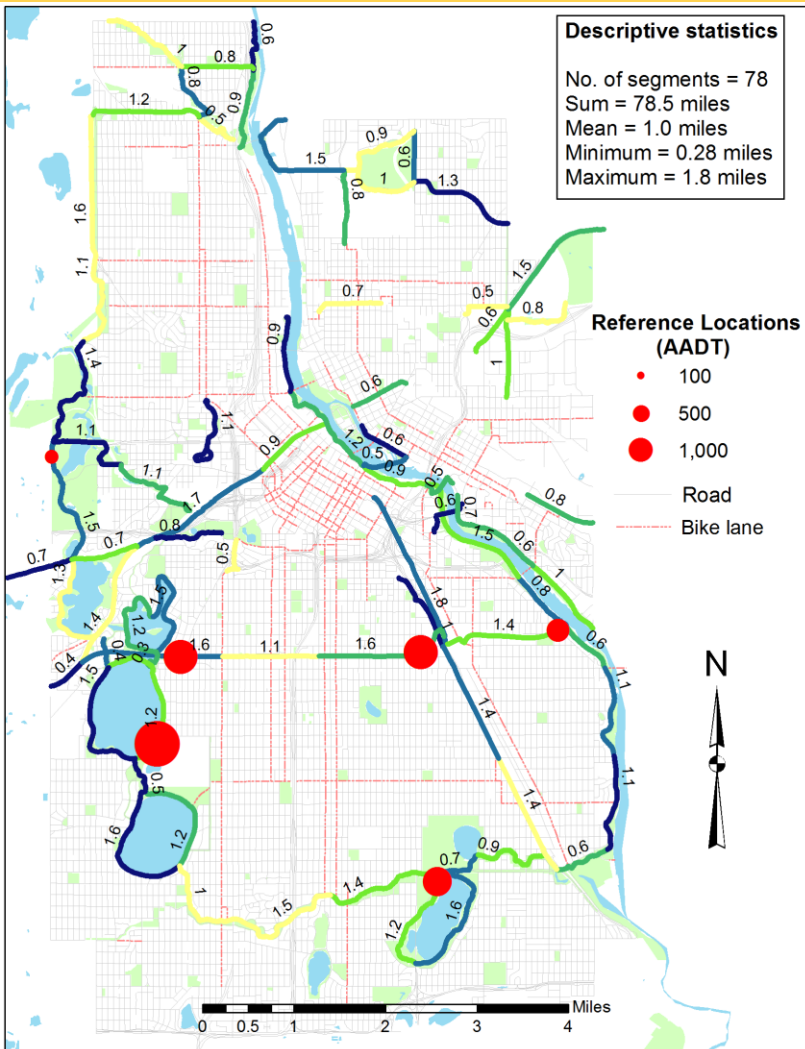
# Automated Traffic Monitoring on Multiuse Trails in Minneapolis



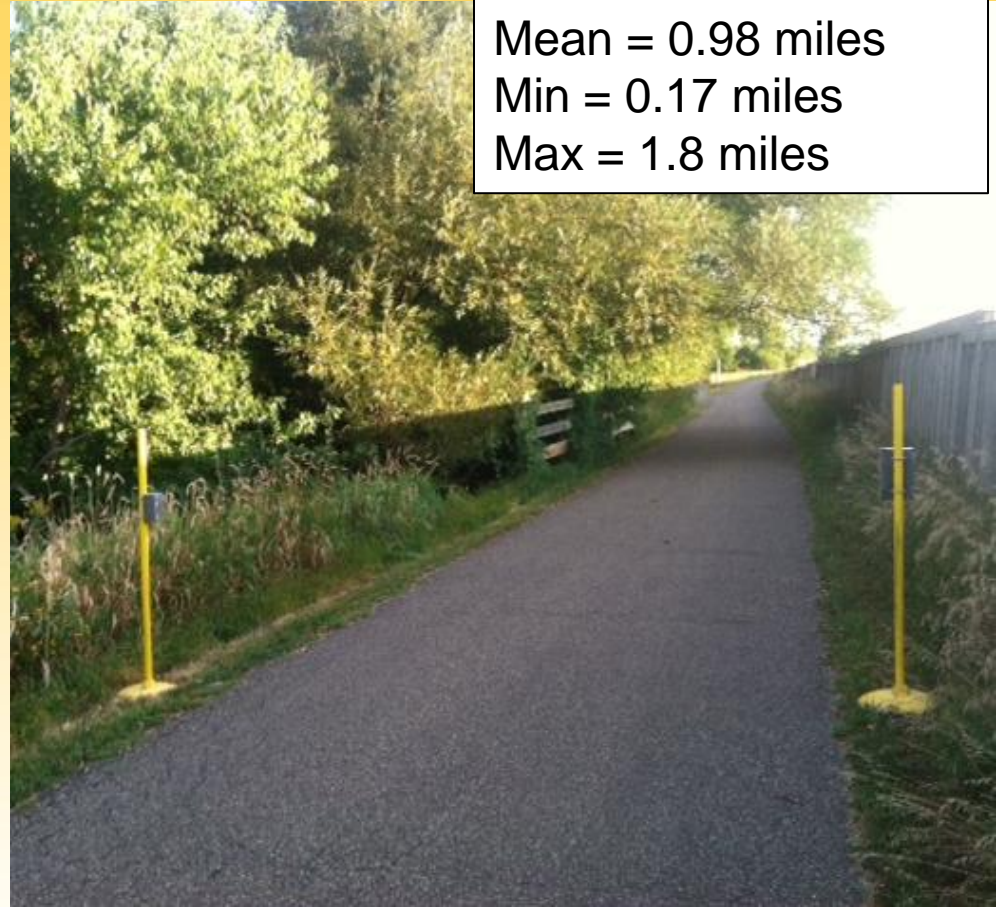
Typical Monitoring Site:  
Midtown Greenway



# Trail Segments for Short-Duration Counts



No. of segments = 80  
Sum = 78.3 miles  
Mean = 0.98 miles  
Min = 0.17 miles  
Max = 1.8 miles



# Infrared Technology

## Reference and Short Duration Sites

- Trail Master (TMI) active infrared counters
  - “Counts” when user breaks beam
  - Does not distinguish bikes and peds
  - Systematic undercount (occlusion – users passing simultaneously)



- Labor intensive
- Old technology



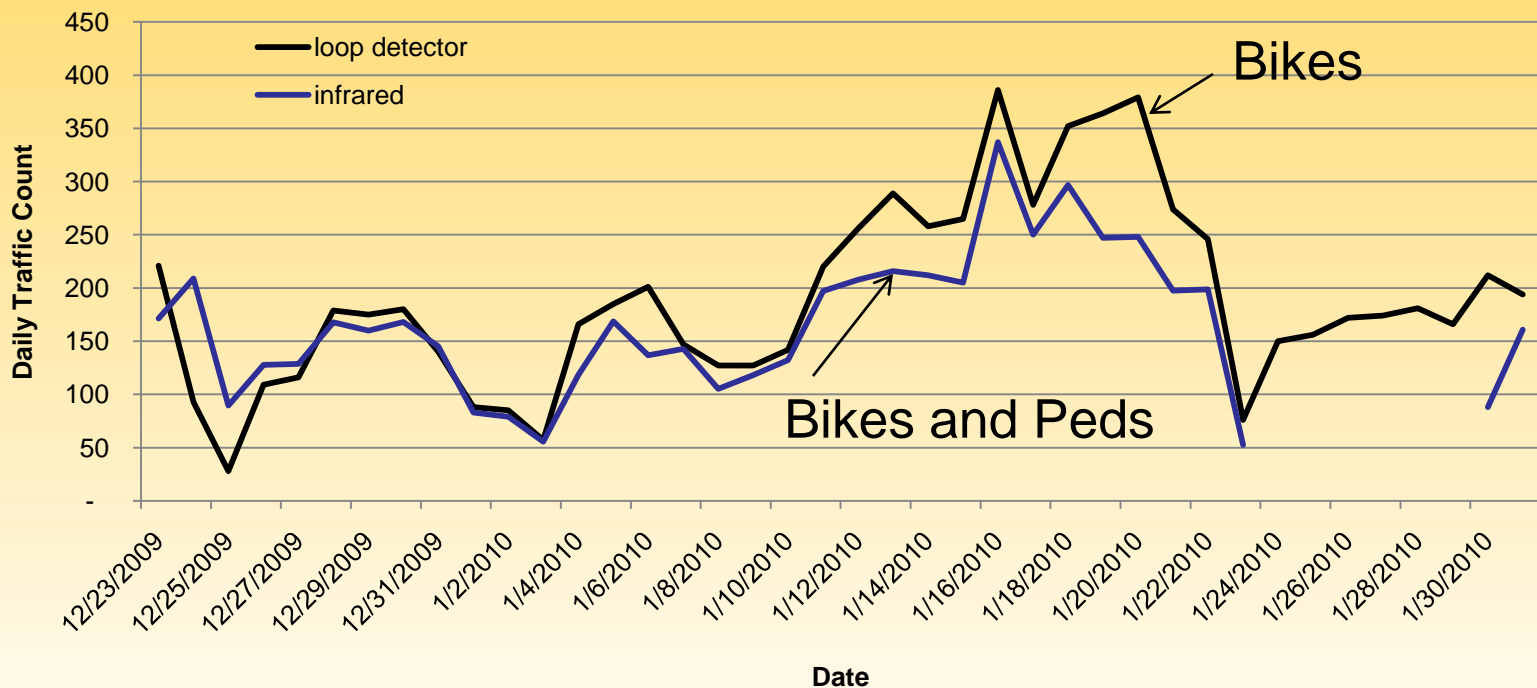
# Inductive Loop Technology – Reference Sites

- Inductive loop counters (3 locations)
  - Counts when bicycles ride over loop in pavement
  - Only counts bicycles
  - Installed by Dept. of Public Works in 2007
  - Counts not validated by city

# QA/QC: A Calibration Problem

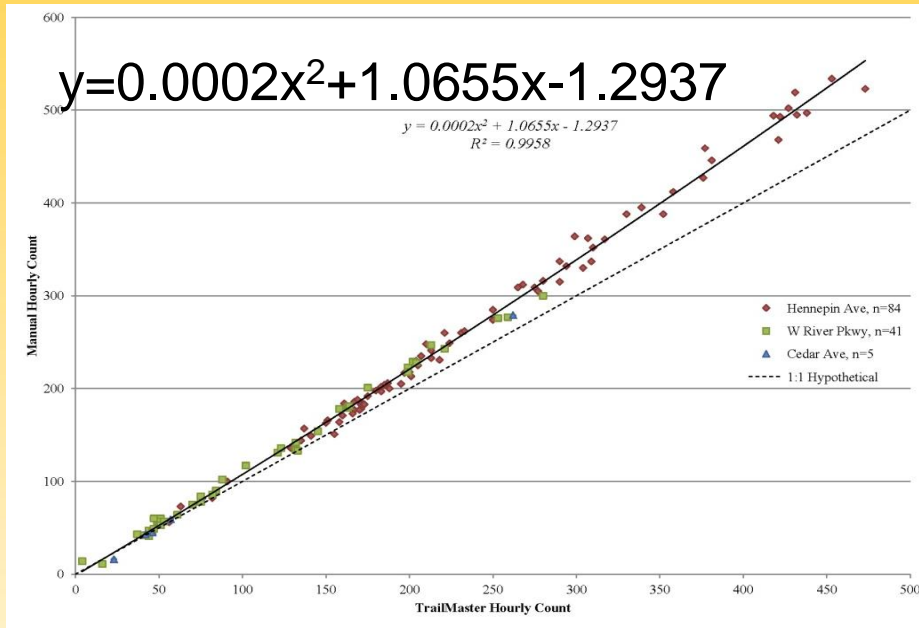
Counts (bikes) > Infrared Counts (bikes & peds)

## Hennepin Ave. Counter Site (Dec 2009 & Jan 2010)



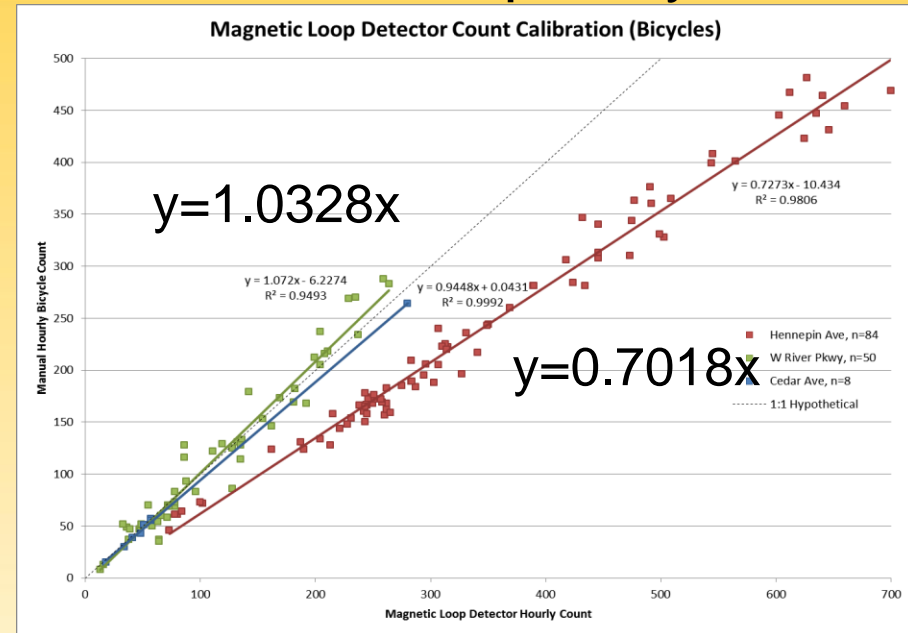
# Quality Assurance / Quality Control

## Active Infrared: Mixed Mode



- Systematic undercounts due to occlusion
- Hourly adjustment equations same across locations

## Inductive Loop: Bicycles



- Over and undercount due to installation, maintenance
- Hourly adjustment equations vary by location

# Correction Equations for Reference Sites by Mode

| Monitoring Location(s)             | Type of Monitor | Mode  | Hours of Validation | Hourly Traffic               |
|------------------------------------|-----------------|-------|---------------------|------------------------------|
|                                    |                 |       |                     | Adjustment Equations*        |
| All six locations                  | Active infrared | Mixed | 130                 | $y=0.0002x^2+1.0655x-1.2937$ |
| Lakes Calhoun and Nokomis          | Active infrared | Peds  | 20                  | $y=1.2920x$                  |
| Lakes Calhoun and Nokomis          | Active infrared | Bikes | 19                  | $y=1.078x$                   |
| Midtown Greenway: Hennepin         | Inductive Loop  | Bikes | 86                  | $y=0.7018x$                  |
| Midtown Greenway: Cedar            | Inductive Loop  | Bikes | 8                   | $y=0.9451x$                  |
| Midtown Greenway: W. River Parkway | Inductive Loop  | Bikes | 51                  | $y=1.0328x$                  |

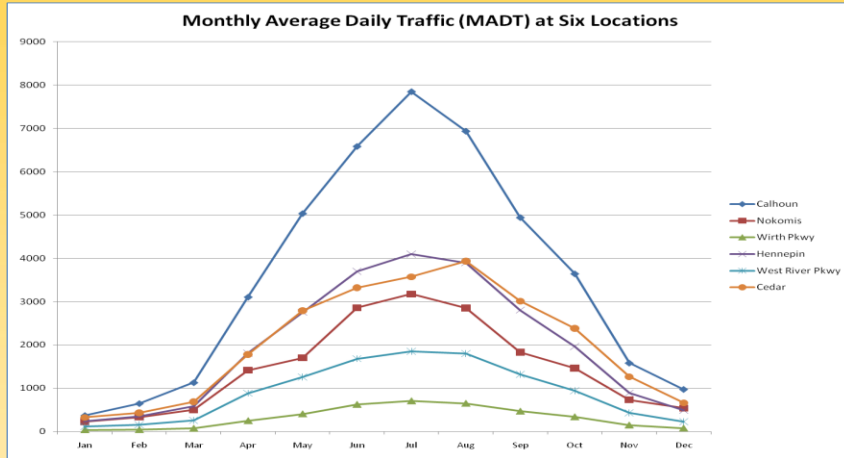
**y = estimated hourly traffic; x = hourly count from monitor**

# Average Annual Daily Trail Traffic

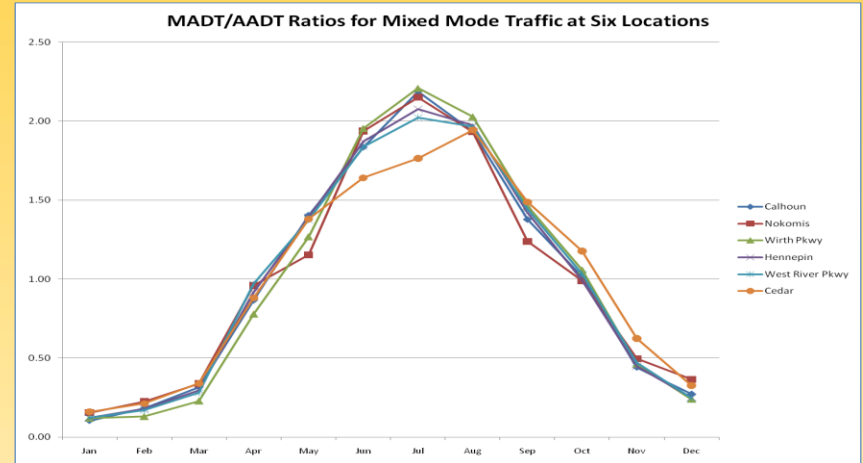
| Location / Mode                                       | Estimated Total Annual Traffic | Estimated AADT | Percent of Traffic at Site |
|---|--------------------------------|----------------|----------------------------|
| <b>(1) Hennepin Ave. &amp; Midtown Greenway (MGW)</b> |                                |                |                            |
| a. Bicycle  | 629,262                        | 1,724          | 87%                        |
| b. Pedestrian   | 91,451                         | 251            | 13%                        |
| c. Total – mixed-mode                                 | 720,714                        | 1,975          | 100%                       |
| <b>(2) West River Pkwy &amp; MGW</b>                  |                                |                |                            |
| a. Bicycle  | 320,198                        | 877            | 96%                        |
| b. Pedestrian   | 13,196                         | 36             | 4%                         |
| c. Total – mixed-mode                                 | 333,395                        | 913            | 100%                       |
| <b>(3) Cedar Ave. &amp; MGW</b>                       |                                |                |                            |
| a. Total – mixed-mode                                 | 738,336                        | 2,023          | 100%                       |
| <b>(4) Lake Calhoun Parkway*</b>                      |                                |                |                            |
| a. Bicycle (outer)                                    | 494,209                        | 1,354          | 38%                        |
| b. Pedestrian (inner)                                 | 814,434                        | 2,231          | 62%                        |
| c. Total – mixed-mode                                 | 1,308,643                      | 3,613          | 100%                       |
| <b>(5) Lake Nokomis Parkway*</b>                      |                                |                |                            |
| a. Bicycle (outer)                                    | 193,843                        | 531            | 36%                        |
| b. Pedestrian (inner)                                 | 344,604                        | 944            | 64%                        |
| c. Total – mixed-mode                                 | 538,448                        | 1,475          | 100%                       |
| <b>(6) Wirth Parkway – mixed-mode</b>                 | 116,765                        | 320            | 100%                       |
| <b>Six Location Mixed-Mode Total</b>                  | <b>3,756,301</b>               | <b>10,291</b>  | <b>100%</b>                |

# Monthly Mixed Mode Traffic Patterns

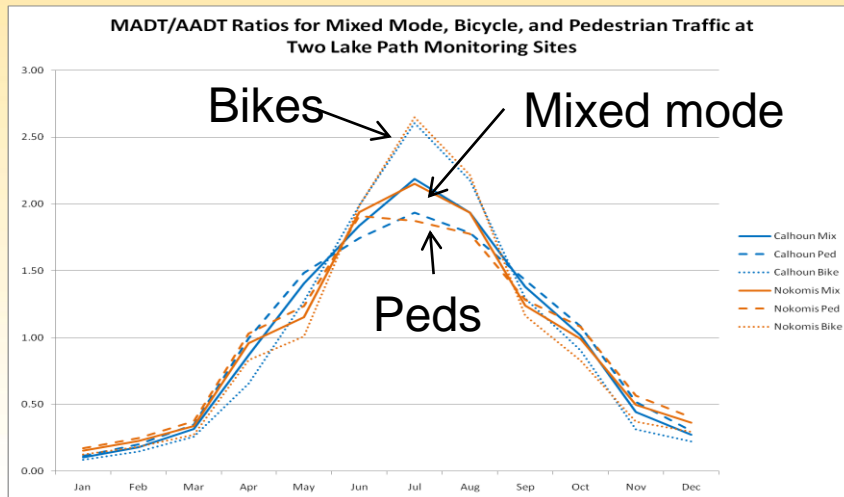
## Monthly mean daily traffic



## Monthly/annual mean daily traffic



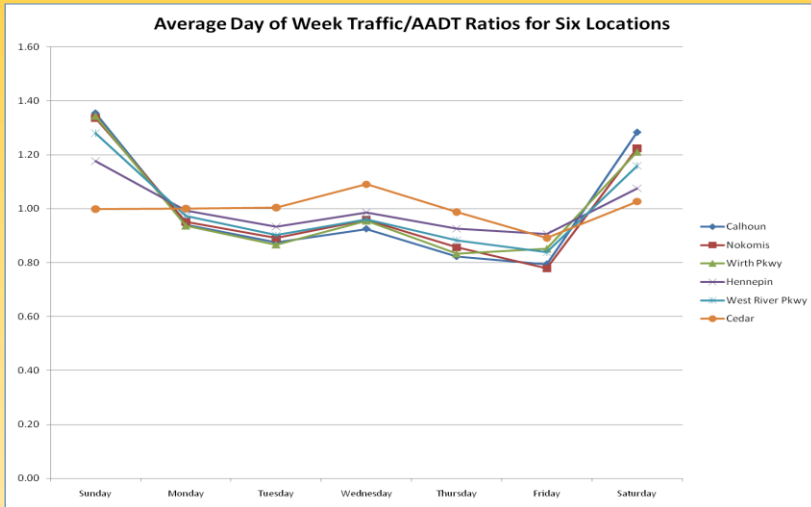
## Monthly/annual mean daily traffic by mode



- Mixed mode traffic varied by an order of magnitude across sites
- Monthly to annual mean daily traffic ratios generally were consistent across sites.
- Bicycle traffic is characterized by greater seasonality than pedestrian traffic.

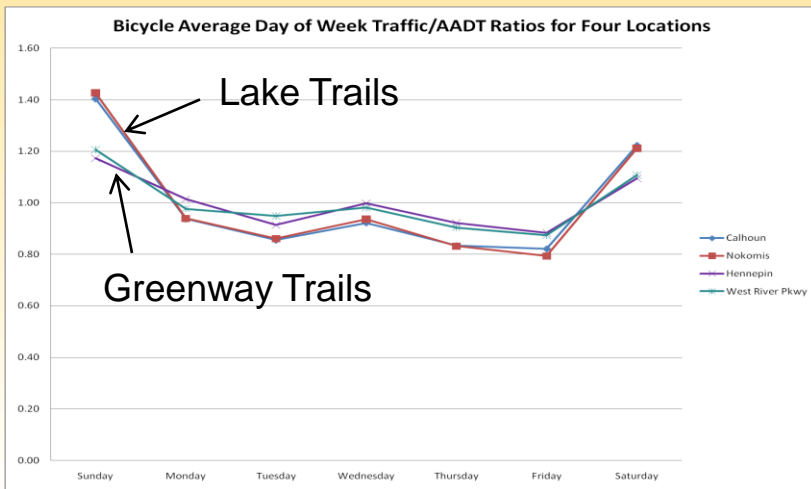
# Mean Day of Week Traffic / Annual Mean Daily Traffic

Mixed mode: six monitoring sites

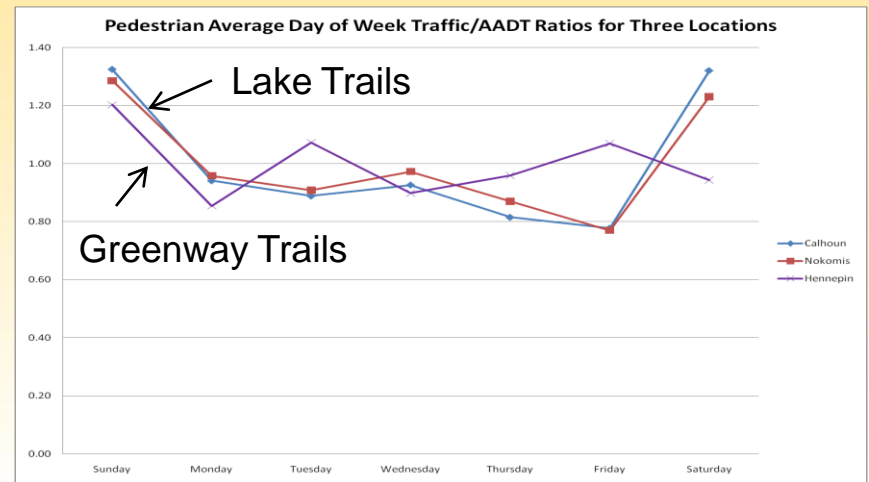


- Mixed-mode day of week scaling factors generally are consistent across locations with higher traffic on weekend days.
- Bicycle day of week factors vary by location, with greater weekend traffic ratios at recreational sites around lakes.
- Pedestrian do not appear to vary as much as bicycle factors but reflect greater day-of-week variability.

Bikes: Mixed recreational and “utilitarian”

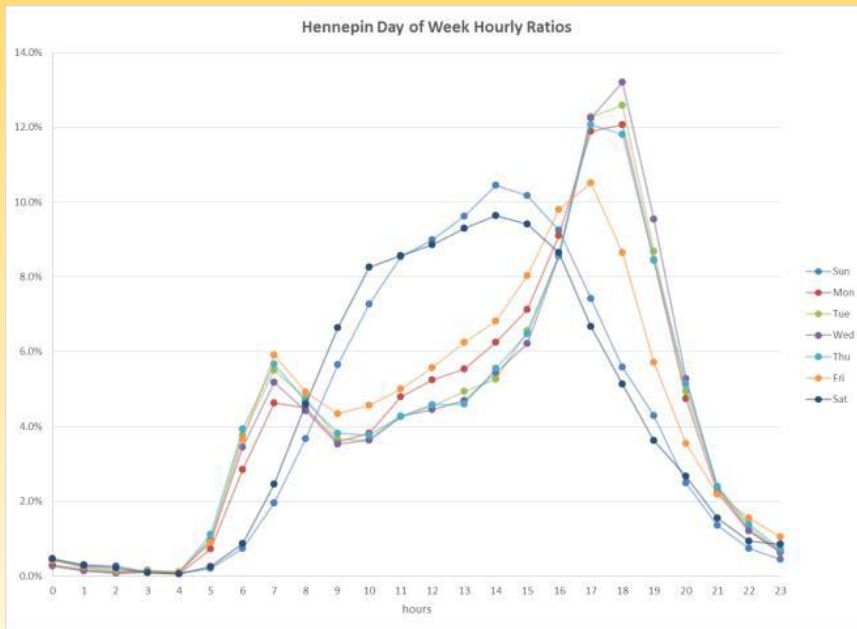


Peds: Mixed recreational and “utilitarian”

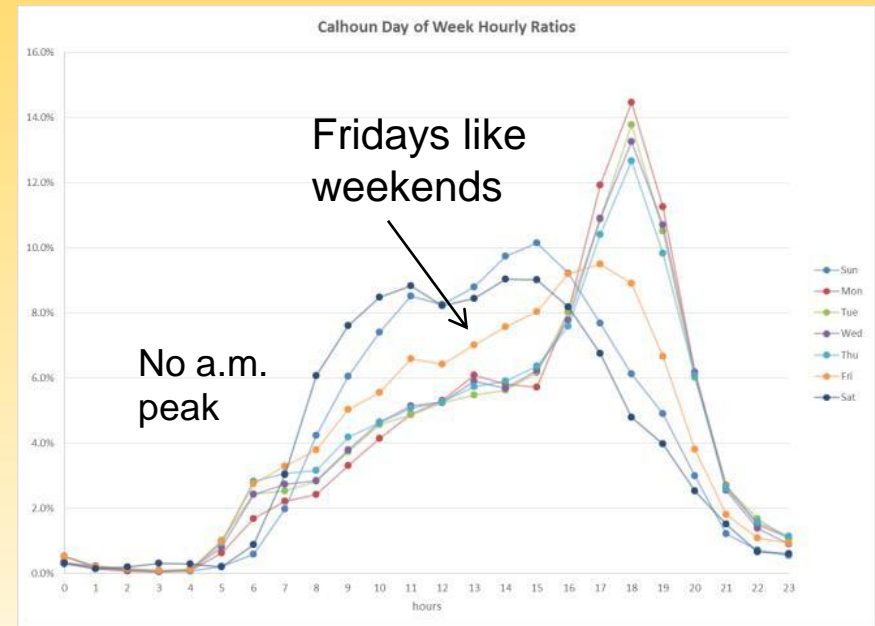


# Weekday and Weekend Hourly Traffic (%)

## Midtown Greenway Hennepin



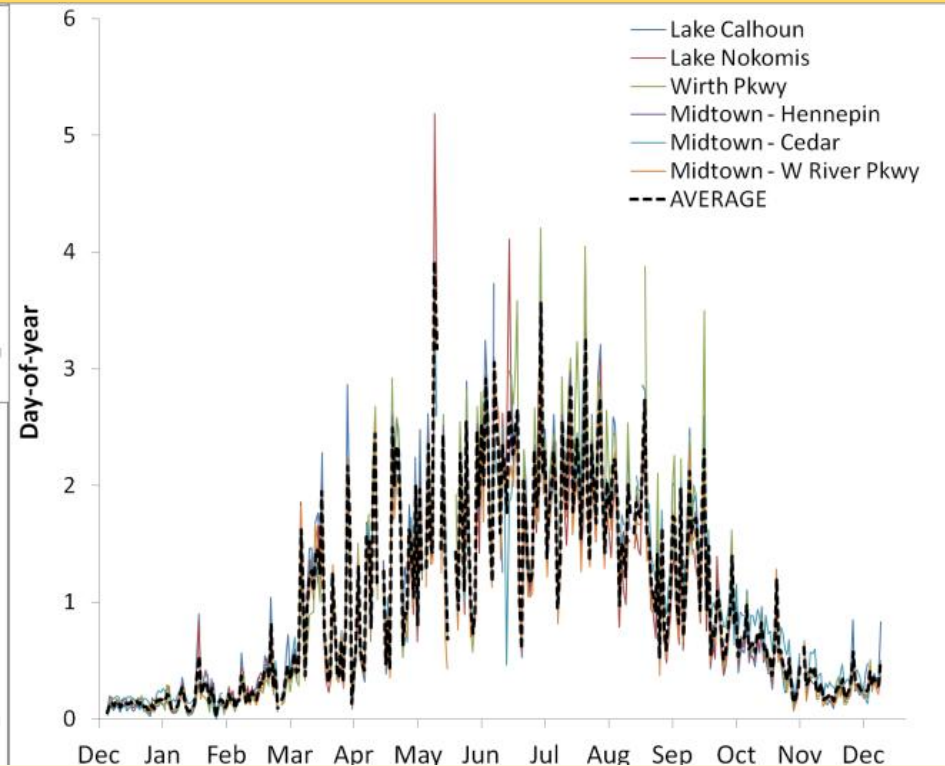
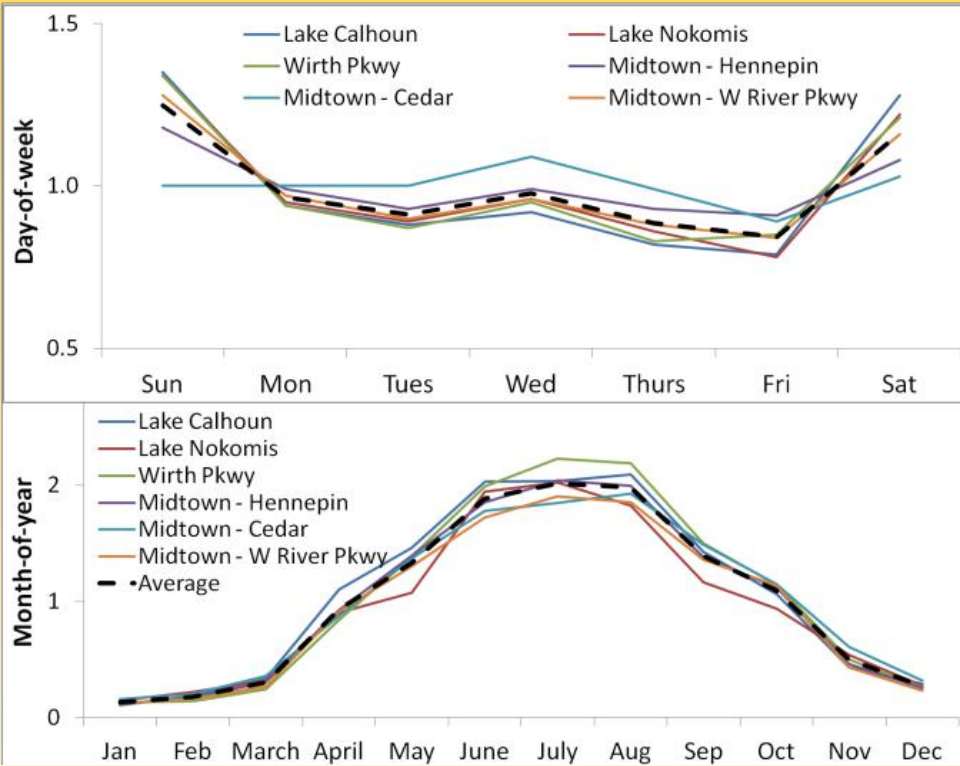
## Lake Calhoun Trail



At lake trail: no morning a.m. peak; Fridays similar to weekend days



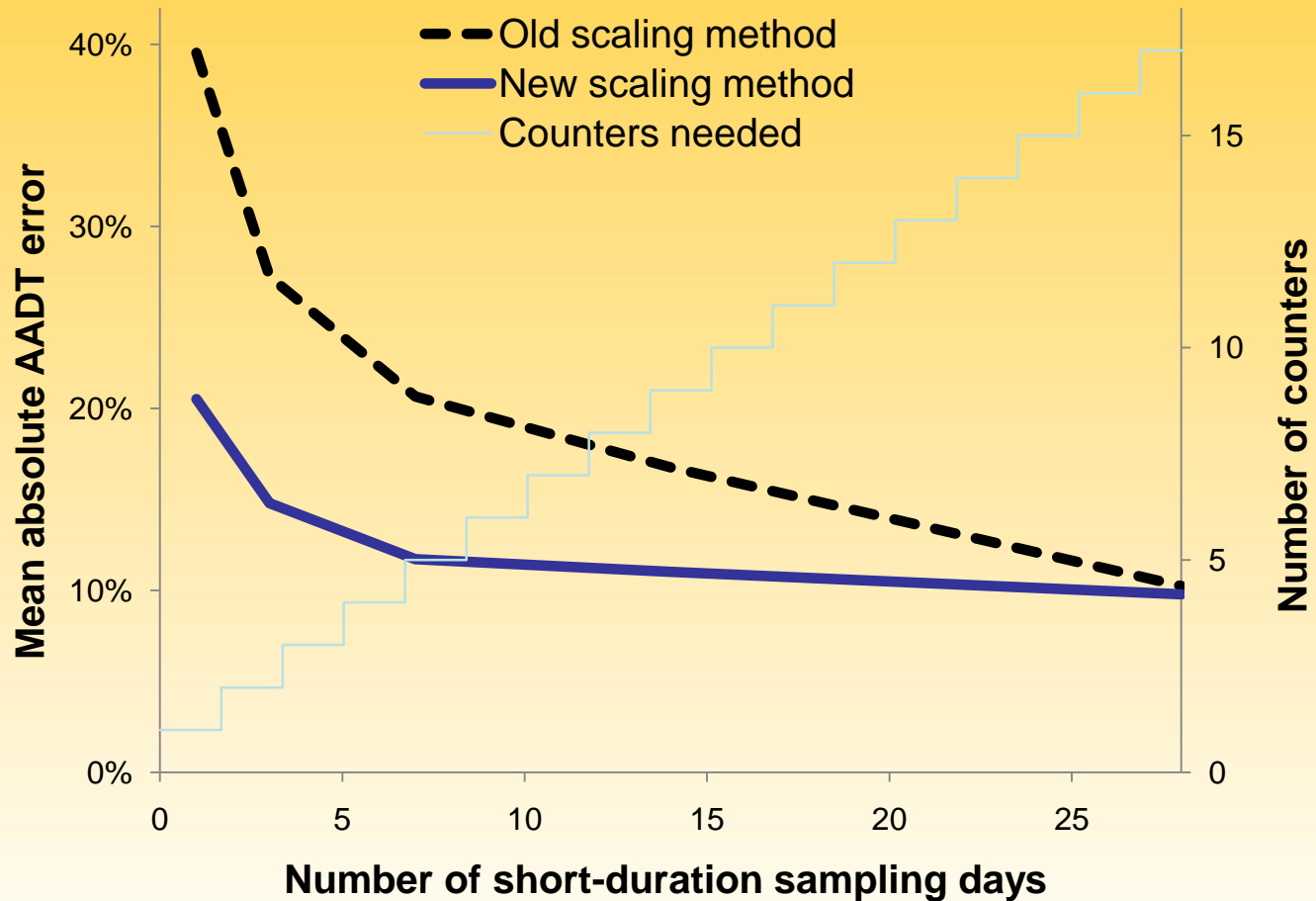
# Adjustment Factors for Short-duration Counts: Day-of-Week, Month-of-Year (old) vs. Day-of-Year (new)



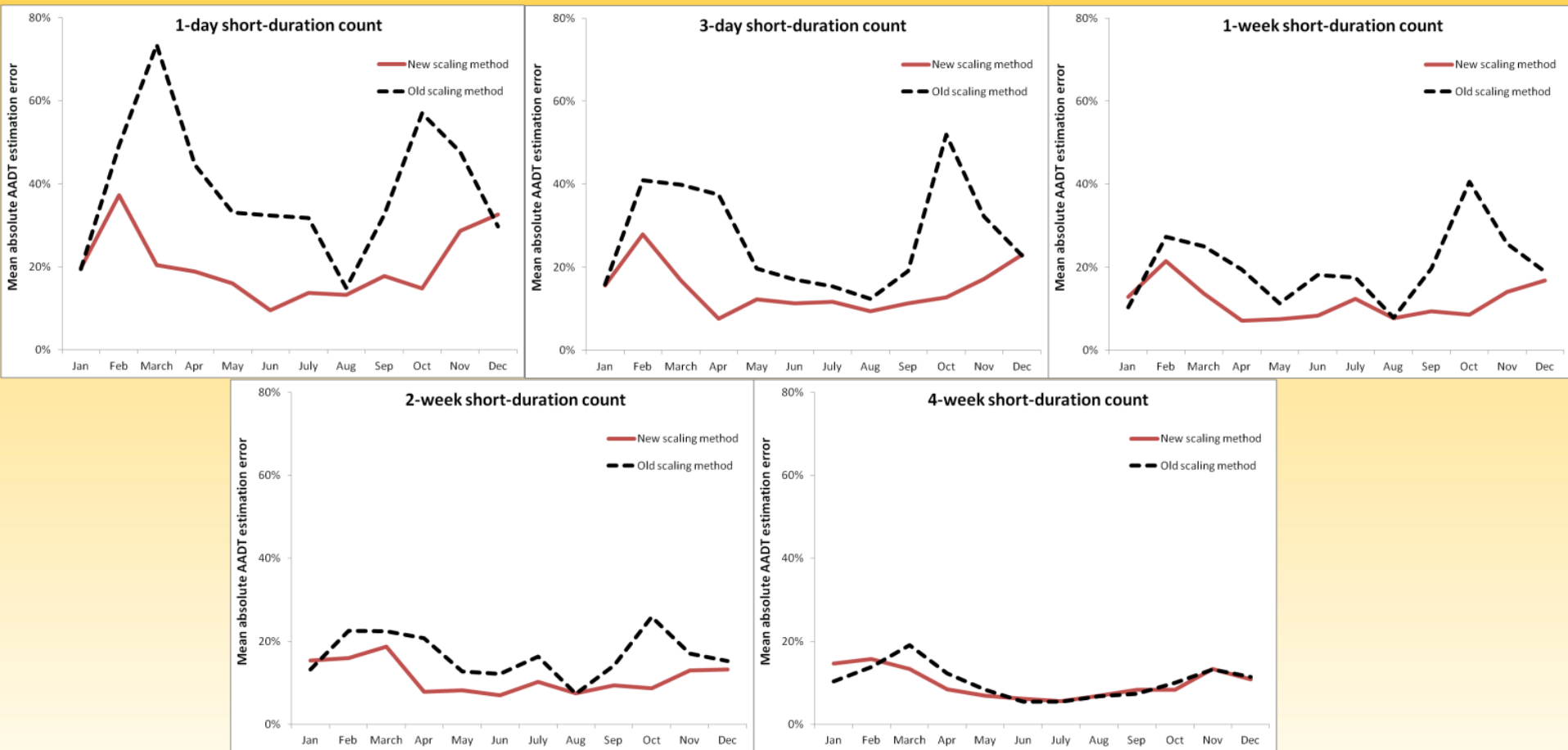
# Comparing Factoring (extrapolation) Methods

- Compute traditional (day-of-week, month-of-year) and new day-of-year factors for five of six reference sites
- Randomly select 50 different 1 day, 3 day, 5 day, 7 day, 14 day, 30 day counts from sixth site
- Use both factoring approaches to estimate AADTT and trail miles traveled for sixth site
- Compare extrapolation error from two factoring approaches

# Day-of-Year Factors Reduce Extrapolation Error

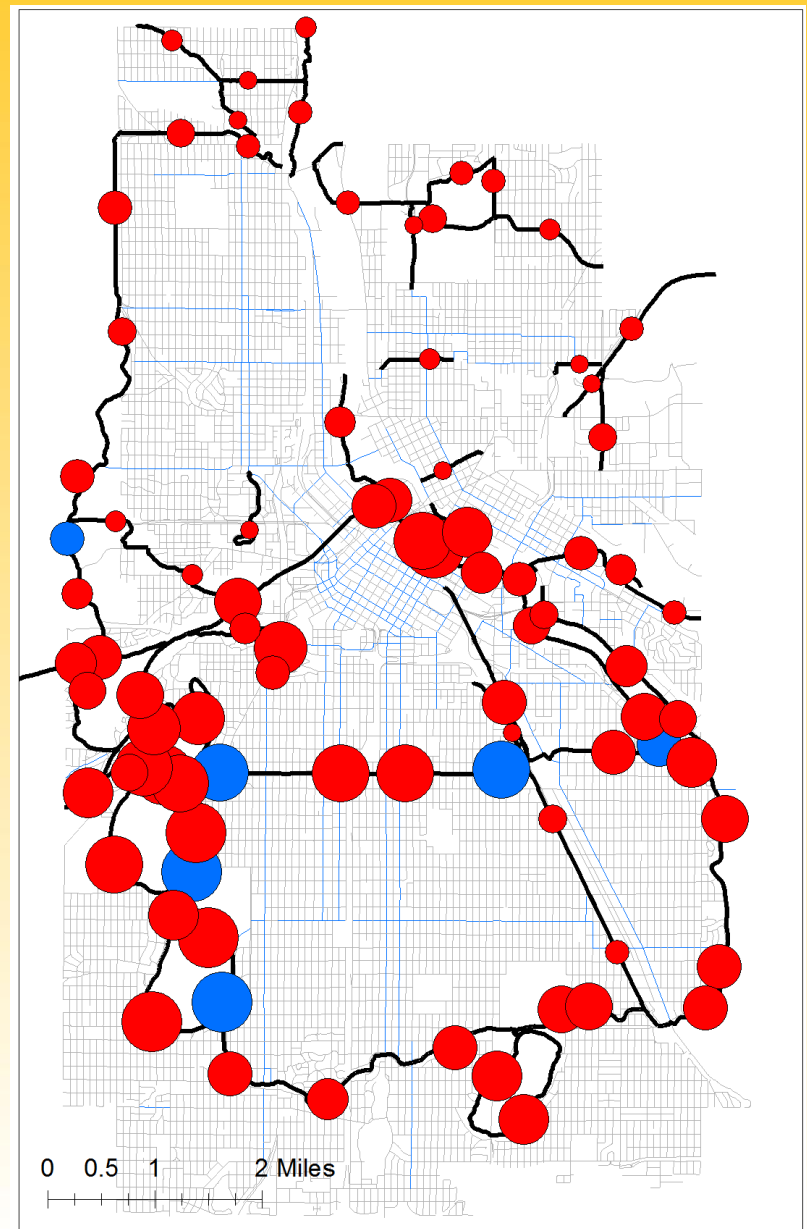


# Sampling from April to October Minimizes Extrapolation Error



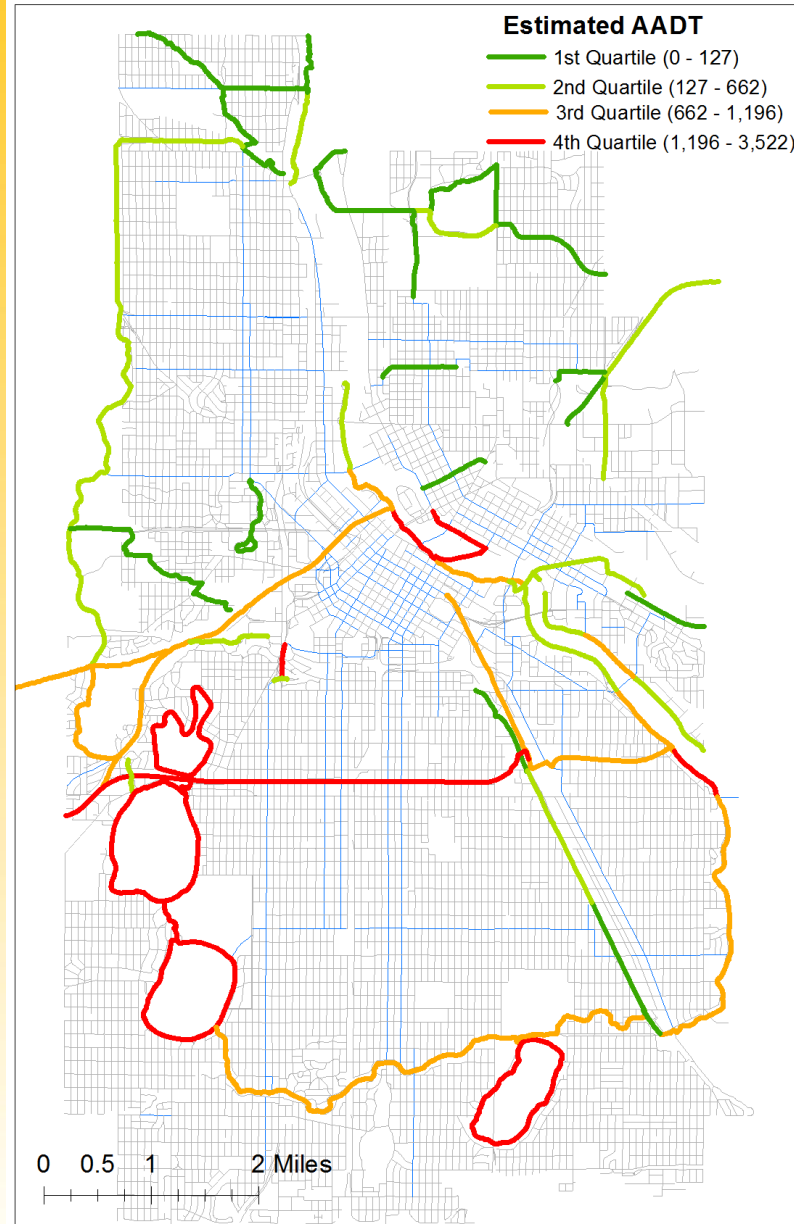
# Average Annual Daily Trail Traffic

| Segment AADT |       |
|--------------|-------|
| Mean         | 954   |
| Median       | 750   |
| Max          | 3,728 |
| P90          | 2,321 |
| P75          | 1,264 |
| P25          | 142   |
| P10          | 81    |
| Min          | 39    |

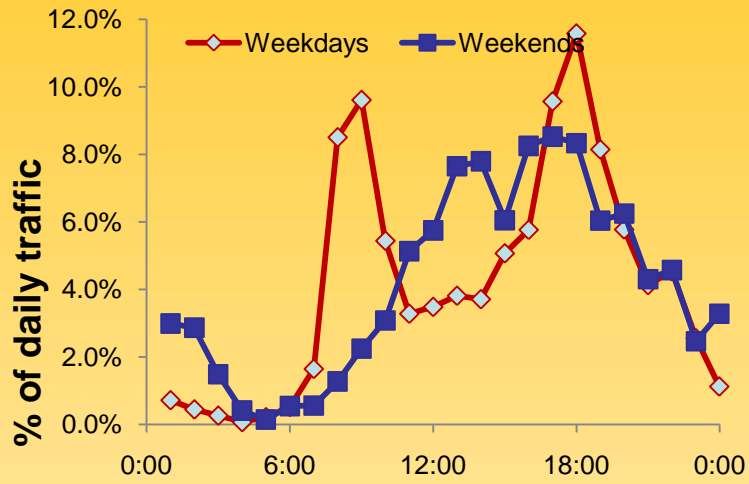


# AADT by Trail Segment

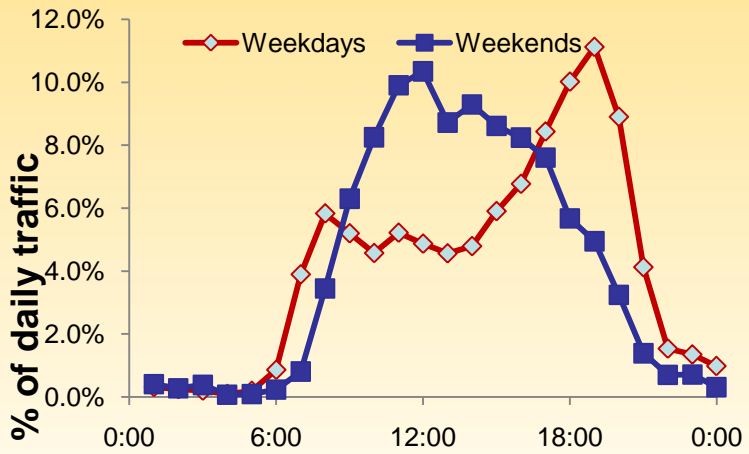
- Estimate: ~28 million user-miles traveled
- Lake, Mississippi River, Midtown Greenway Trails most heavily used
- Patterns reflect flows to central business district, university
- Trails in north Minneapolis (low income, minority populations used least)



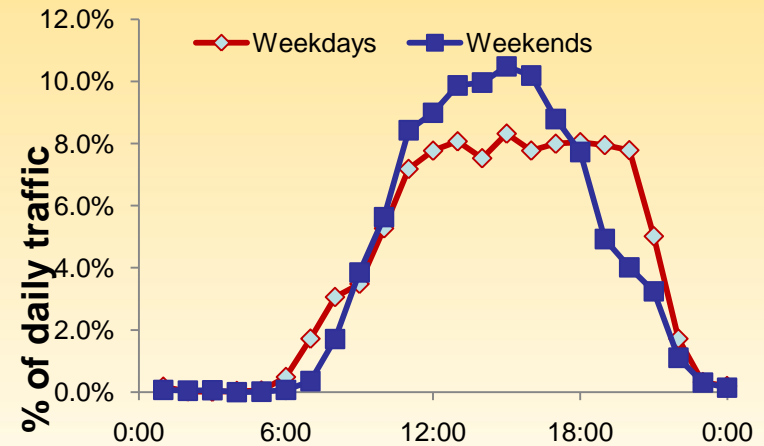
Short-duration monitoring identified three different traffic patterns (factor groups). Need new reference monitoring sites.



Utilitarian (weekday)



Mixed Recreational – Utilitarian (all current reference locations)



Recreational

# Some Observations

- Traffic volumes on shared-use paths significant
- Systematic error in existing counts (occlusion)
- Volumes vary substantially across locations
- Mode-mix varies substantially across locations
- Traffic follows hourly, daily, monthly patterns
- Patterns vary across locations
- New day-of-year adjustment factors reduce error in extrapolation (10-15%)
- Can estimate miles traveled on trail network



# Some Limitations and Next Steps

- New day-of-year factors can only be applied retrospectively (at end of year)
- Need to reconfigure reference sites and install reference counters for each factor group
  - Utilitarian, mixed utilitarian-recreational, recreational
- Need to assess current segment breaks
  - Adjust to reflect variation in flow, increase accuracy?
- Need to develop factors for different modes (bikes, peds)
- Need to integrate findings into trail operations

# Questions?

For more information contact:

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