Counting Pedestrians and Cyclists on Multiuse Trails and Other Facilities

HUMPHREY SCHOOL
OF PUBLIC AFFAIRS

UNIVERSITY OF MINNESOTA
Driven to Discover[SM]

Trail Counting Workshop

- How many are researchers?
- How many are policy-makers, public managers, or advocates?
- How many are now counting users?
- Why count?

- Goal is exchange of information.
- Please ask questions.

Why Count?

- Document use of facilities
- Allocate resources
- Assess efficiency of investments
- Optimize trail operations & maintenance
- Assess exposure rates and need for safety interventions
- Improve systems planning
- Inform and conduct research

The Scientific Method and Public Management

<u>**Research Paradigm**</u> **Scientific Method: focused on producing knowledge; knowledge is end.**	<u>**Management Paradigm**</u> **Problem-Solving Process: focused on changing status quo; knowledge is instrumental.**
1. Observation	1. Goals / Problem Definition
2. Hypothesis	*2. Data collection and analysis*
3. Experiment	*3. Development of alternatives*
4. Data collection and analysis	*4. Evaluation of alternatives*
5. Accept or reject hypothesis	5. Selection of alternative
6. Publish results	6. Implementation

Using Counts in Public Management

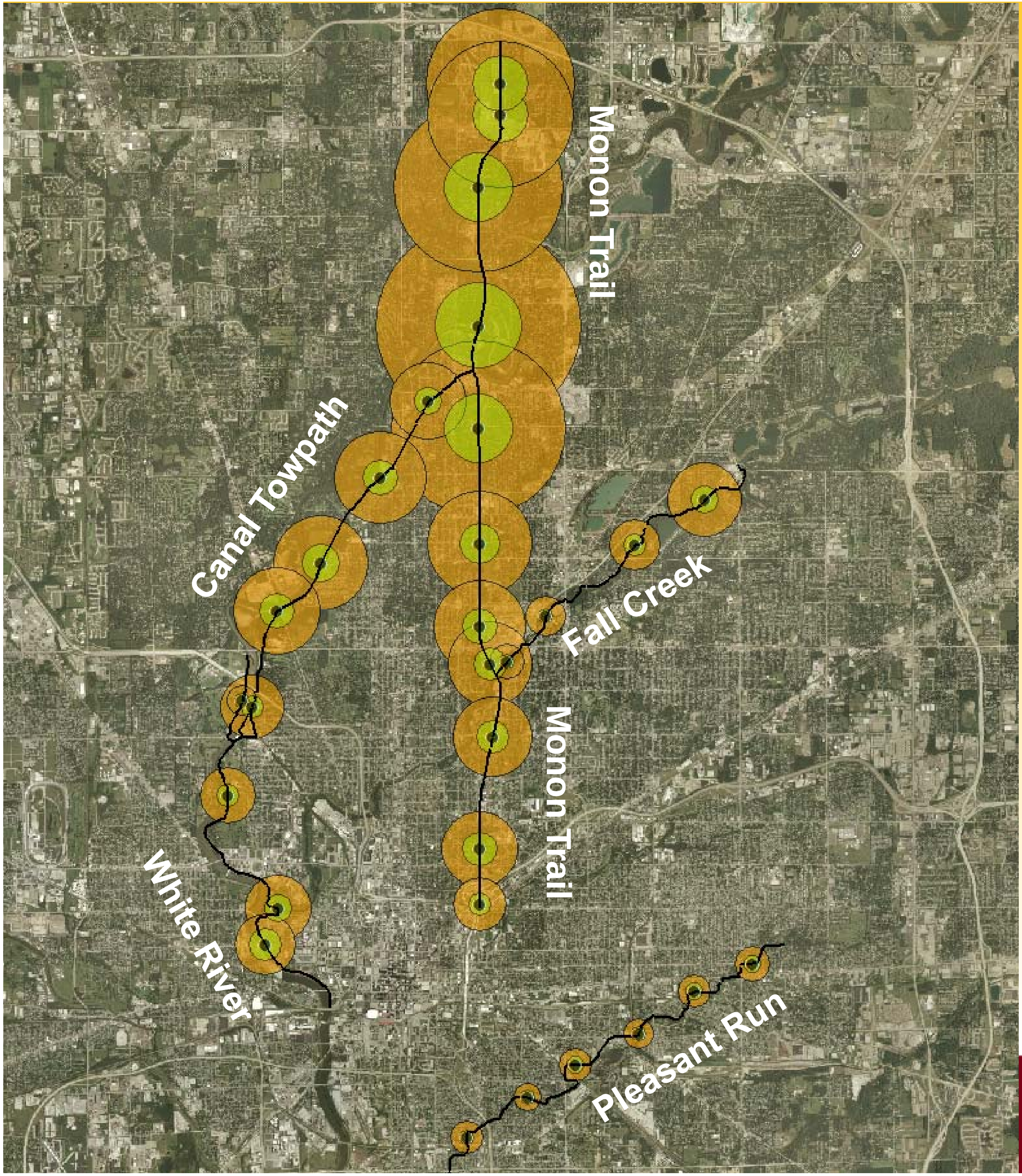
- Documenting facility use: Greenways Division, City of Indianapolis, IN
- Resource allocation: Indiana Department of Natural Resources
- Traffic control: Department of Public Works, Minneapolis, MN
- Bike facility planning: St. Paul, MN

Monon Trail

Canal Towpath

White River Trail

Pleasant Run

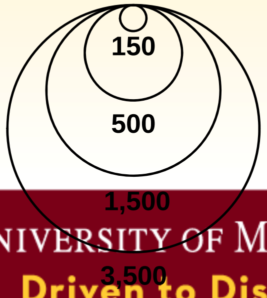


Understand Spatial & Temporal Variation in Trail Traffic, Indianapolis, IN (9/04)

	Min	Max	Mean
Week Days	79	2,017	436
Weekend Days	105	3,670	834

Annual Trail Traffic

- Maximum: 606,900
- Minimum : 21,700
- Mean: 146,438
- Median: 101,578



Inform Resource Allocation

- Demand (potential use) of facilities typically not estimated
- Indiana 2004-2005 Trail Funding Program
  - 66 applications; $73 million requested
  - Only 20 applicants estimated use in proposal
- ***Mean*** predicted use: ***22%*** higher than segment in Indianapolis with ***highest*** traffic volume
- Median predicted use more than double median traffic volume on 30 sites
- Estimates of potential trail use can inform and increase efficiency of investment decisions

Inform Traffic Safety: Street-Trail Crossings

Street (mid-block crossing)	Street Average Daily Traffic	Trail Estimated Daily Traffic	Recommendations (selected)
Local 1	420	3,280	Add street stop sign; remove trail stop sign
Local 2	2,026	3,280	Add street stop sign; remove trail stop sign
Local 3	2,400	3,280	Add street stop sign; remove trail stop sign
Local 4	1,680	2,900	Add street yield sign; remove trail stop sign
Minor Arterial	7,267	2,740	Trail stop sign, add overhead flasher; reduce vehicles lanes from 4 to 2 at crossing
Minneapolis Dept. of Public Works , Feb. 15, 2010			

Inform Bike Facility Planning

- Proposed Bike Boulevard, St. Paul
  - Neighbors concerned about increases in bike traffic
  - No estimates of potential use available; no methods for estimating
- Use counts from Minneapolis to "guestimate"

	Local Street with Bike Facility (n=11)	Local Street with no Bike Facility (n=52)
12-hour traffic	387	277
• Presence of bike lane: 40% greater bike traffic		
• 100 events / 12 hour day = 8 more bikes / hour = 1 more bike / 7 minutes		
• Key assumption: bike traffic on local streets with and without bike facilities similar across cities (not good but better than nothing)		

Learning Objectives

- How counts of pedestrians and cyclists can inform research, policy, and management,
- How to assess strengths and weaknesses of different methods of counting
- How to develop and use simple planning ratios for extrapolating counts of pedestrians and cyclists
- How to understand approaches to modeling pedestrian and bicycle traffic on facilities
- How to participate in the National Bicycle & Pedestrian Documentation Project

Before Counting

- Define problems or questions
- Different information needed for different questions
  - Facility traffic counts needed for planning, design, and operations
  - Visitor trips needed for benefit-cost analysis
  - Frequency, intensity, and duration of individual trips for health impact analysis
- Choose appropriate methods (e.g., counts vs. surveys)

Some Terms

- **<u>Traffic count</u>**: user past a point; may be same user multiple times on single trip
- User visit: distinct trip by an individual to a facility (may be multiple trips in a day or week by same individual)
- Individual physical activity: frequency, intensity, and duration of use of facility within specified time period

National Bicycle and Pedestrian Documentation Project

- Institute of Traffic Engineers; Alta Planning & Design
- Initiated in 2002, volunteer (not funded)
- Goal is standard methods and national database
- Consistent count dates, times, methods, procedures
  - Purposive (not random) sampling
  - Volunteer training guides
  - Forms for counting
  - Formats for spreadsheets and methods for tabulating
  - Guidelines for submitting

Methods of Counting

- **Field observation**
- **Active infrared**
- **Passive infrared**
- **Magnetic loop detectors (in pavement)**
- Pressure sensors (piezometric)
- Video imaging, ultrasonic, dopplar radar

Factors to Consider

- How counters work
- Type of data generated
- Quality of data generated; need for calibration
- Ease of deployment (e.g., location, type of facility, relocation)
- Cost of deployment
- Choice of methods is all about trade-offs

Minneapolis Example: Methods of Counting

Method of observation	Manual	Magnetic Loop Detector	Active Infrared Counters (beam/sensors)
Traffic observed	Cyclists (bi-directional) Peds (bi-directional)	Cyclists only (bi-directional, potentially)	Cyclists & Peds combined (no directional)
Output	Choice of time units	15 minute blocks	Time of event
Locations for deployment	On and off-street facilities & no facilities	Off-street facilities	Depends on counter type and facility characteristics
Length of observations	Based on staff availability (often two-hour blocks)	Continuous: 24 hours	Continuous: 24 hours
Limitations	Human error	Must calibrate	Must calibrate; systematic undercount (beam counters)

Minneapolis Example: Methods of Counting, con't.

Method of observation	Manual	Magnetic Loop Detector	Active Infrared Counters (beam/sensors)
Sources of error	Distractions	Misses riders on edge of trail.	Misses users passing simultaneously
		Direction of riders in wrong lanes recorded incorrectly	
Data recorded	5 – 60 minute time intervals	15 minute counts	Time of "event"; can be aggregated to any time period
Other considerations	Can record groups, some user characteristics	Can't measure user characteristics	Can't measure user characteristics

Considerations in Field Observations

- Need to determine length of sample (< one hour, 1-2 hours, peak hour(s), 12 hours)
- Need to choose locations, number of samples
- Very difficult to collect all information of interest from research perspective: count, gender, race, age, direction, group size, helmet, …
- Traffic volumes can be very high, distractions common
- Errors in counting are common

Field Observation: Counting Sheet

(Indianapolis, IN, 2004)

- Five minute intervals
- Walkers, cyclists, runners, skaters, babies, other, total, groups, males, females

Hour ___	Walk	Cycle	Run	Skate	Babies	Other	Total	Groups	Male	Female
____ 00:00 - 04:59										
05:00 - 09:59										

NBPDP Standard Form

- Count for two hours in 15 minute increments.
- Count bicyclists who ride on sidewalk.
- Count number of people on bicycle, not number of bicycles.
- Pedestrians include people in wheelchairs or … strollers
- People using equipment … rollerblades … in other …

	Bikes		**Pedestrians**		**Others**
	Female	Male	Female	Male	
00 - :15					
15 - :30					
30 - :45					
45 – 1:00					
1:00 – 1:15					

Assess Reliability of Manual Counts

Average hourly inter-observer error = 1.4% (n=8)

Comparison Hour	Date	Start Time	End Time	Counter #1	Counter #2	Abs Val Error	Abs Val % Error
1	29 July 2010	9:00	10:00	188	183	5	2.7%
2	29 July 2010	10:00	11:00	183	180	3	1.6%
3	29 July 2010	11:00	12:00	184	183	1	0.5%
4	29 July 2010	12:00	13:00	197	205	8	4.1%
5	29 July 2010	13:00	14:00	218	219	1	0.5%
6	29 July 2010	14:00	15:00	230	233	3	1.3%
7	05 August 2010	11:00	12:00	184	184	0	0.0%
8	05 August 2010	12:00	13:00	202	201	1	0.5%

Estimating Hourly Counts from Samples

- *Predicting Pedestrian Crosswalk Volumes* (Davis, King, and Robertson 1991)
  - Used 5, 10, 15, and 30 minute counts to predict hourly crosswalk volumes
  - Middle 30 minutes is most accurate, but middle 5 is most efficient
- Expansion equations tested for trail traffic (Lindsey & Lindsey 2004)

Expansion Equations for Sample Counts

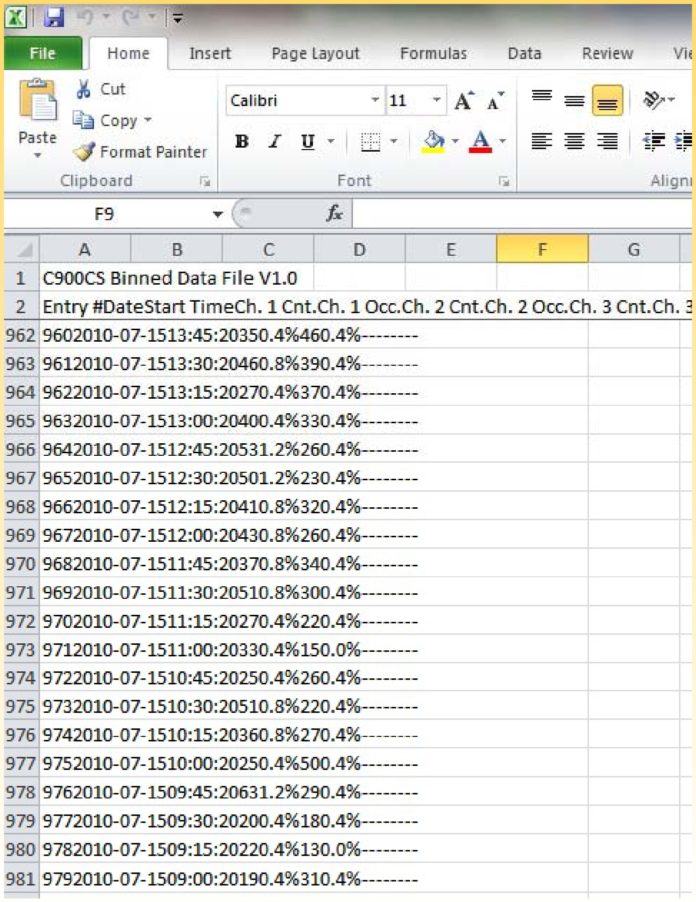
Davis, King, and Robertson (1988)			Lindsey & Lindsey (2004)		
Counting Intervals (minutes)	Equations	R^2	Counting Intervals (minutes)	Equations	R^2
Middle 5	$V_1=19.91*I_5^{.7862}$	0.77	Random 5	$V_1=23.196*I_5^{.6353}$	0.69
Middle 10	$V_1=9.82*I_{10}^{.8465}$	0.86	First 10 Middle 10	$V_1=11.472*I_{10}^{.7662}$ $V_1=12.543*I_{10}^{.7318}$	0.77
Middle 15	$V_1=5.75*I_{15}^{.8996}$	0.91	Last 15	$V_1=7.252*I_{15}^{.7918}$	0.87
Middle 30	$V_1=2.37*I_{30}^{.9625}$	0.96	Middle 30 Last 30 Random 30	$V_1=2.41*I_{30}^{.9517}$ $V_1=2.624*I_{30}^{.9196}$ $V_1=2.82*I_{30}^{.9128}$	0.94

Estimating Hourly Counts from Samples

- Pedestrian cross-walk expansion equations
  - are a-theoretical
  - fit data better than equations estimated from trail traffic counts (larger samples)
  - Indicate hourly volumes are essentially double half-hour volumes
- Decision on length of sample period depends on information needs, costs

Magnetic Loop Detector

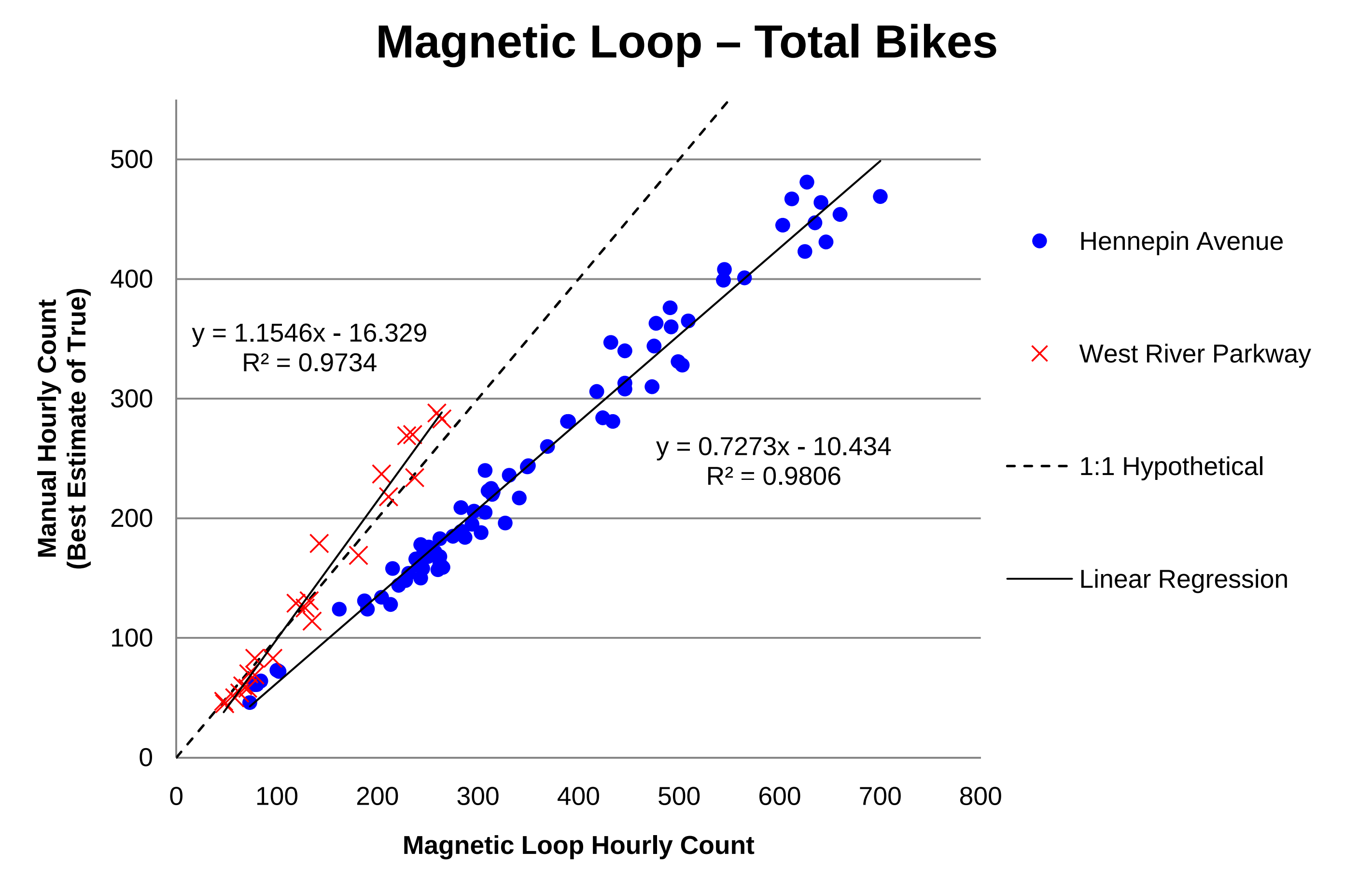
Raw Data



- Data reported in comma-separated-value (.csv) file in 15-minute increments
- Report two “channels” – one for each painted lane
- Cyclists riding in wrong lane can confound directionality results
- Holds 3 months of data
- Can be imported to Excel
- Counter error may differ among locations

l1

Calibrating Magnetic Loop Detector Counts (bikes)



Slide 27

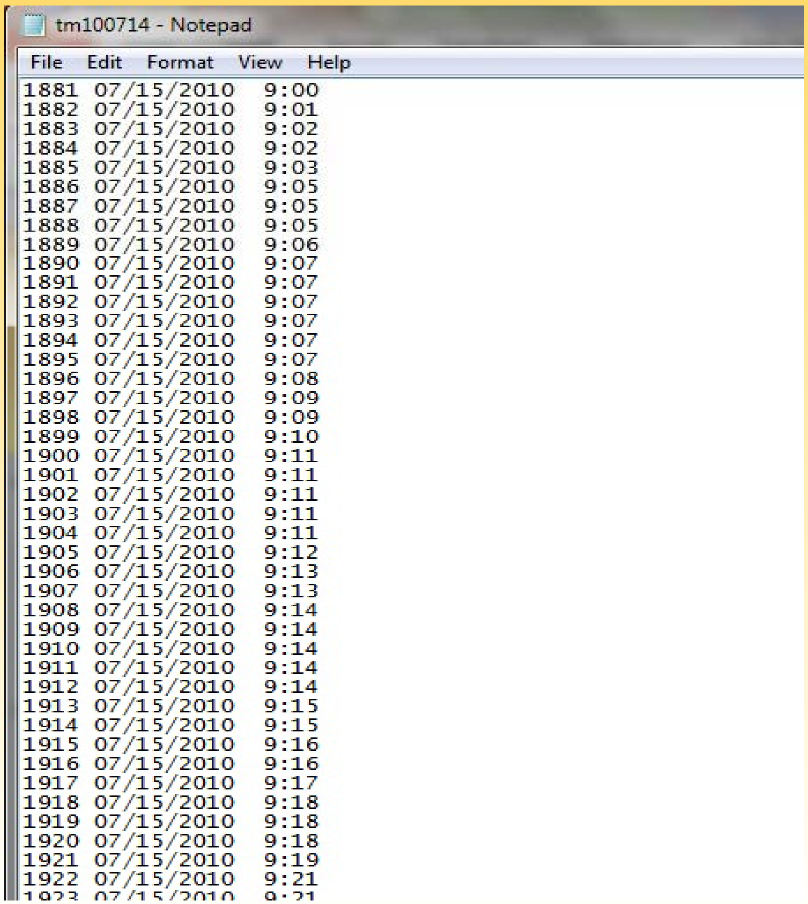
l1 On all these, I understand the ppt title is a more general category. Even so, -since the ppt slide title and the graph title are essentially the same, I would just go with the graph, drop the ppt title, and make the image bigger so people can read it. see next slide.-

linds301, 8/31/2010

Active Infrared Trail Monitors

(Trailmaster ®, bikes & peds)

Raw Data



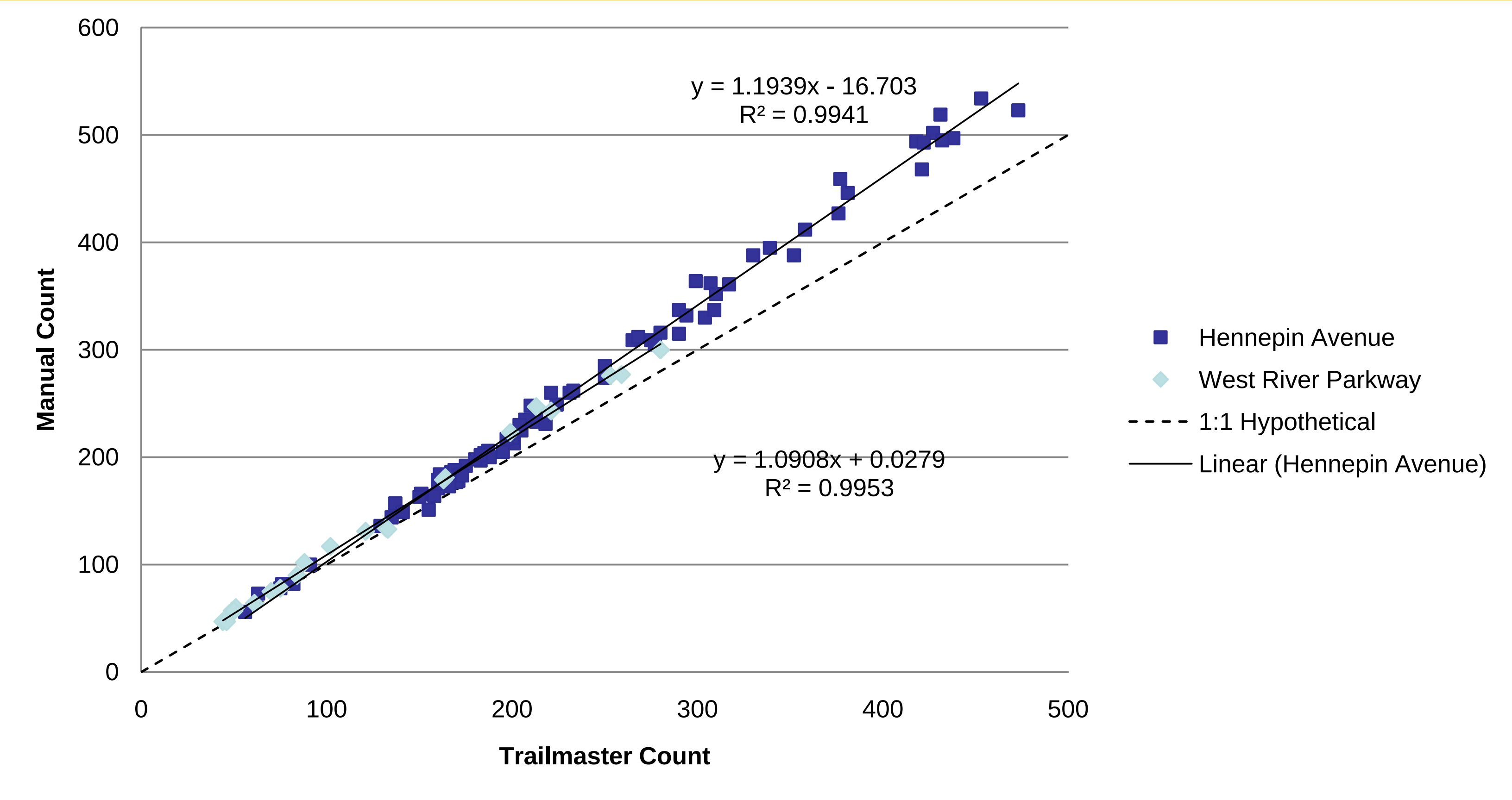
```
tm100714 - Notepad
File  Edit  Format  View  Help
1881 07/15/2010  9:00
1882 07/15/2010  9:01
1883 07/15/2010  9:02
1884 07/15/2010  9:02
1885 07/15/2010  9:03
1886 07/15/2010  9:05
1887 07/15/2010  9:05
1888 07/15/2010  9:05
1889 07/15/2010  9:06
1890 07/15/2010  9:07
1891 07/15/2010  9:07
1892 07/15/2010  9:07
1893 07/15/2010  9:07
1894 07/15/2010  9:07
1895 07/15/2010  9:07
1896 07/15/2010  9:08
1897 07/15/2010  9:09
1898 07/15/2010  9:09
1899 07/15/2010  9:10
1900 07/15/2010  9:11
1901 07/15/2010  9:11
1902 07/15/2010  9:11
1903 07/15/2010  9:11
1904 07/15/2010  9:11
1905 07/15/2010  9:12
1906 07/15/2010  9:13
1907 07/15/2010  9:13
1908 07/15/2010  9:14
1909 07/15/2010  9:14
1910 07/15/2010  9:14
1911 07/15/2010  9:14
1912 07/15/2010  9:14
1913 07/15/2010  9:15
1914 07/15/2010  9:15
1915 07/15/2010  9:16
1916 07/15/2010  9:16
1917 07/15/2010  9:17
1918 07/15/2010  9:18
1919 07/15/2010  9:18
1920 07/15/2010  9:18
1921 07/15/2010  9:19
1922 07/15/2010  9:21
1923 07/15/2010  9:21
```

- Detects each trail user as infrared beam is broken and records timestamp
- Maximum 16,000 observations
- Data reported in text file as stream of dates/times
- Can be imported to Excel as space-delimited text file

Active Infrared Monitors: O&M may be challenging …

I2

Calibrating Active Infrared Counts (bikes & peds)



l2 For this graph, I'd return to the blue dots and red crosses for locations. THis is clearer, and there's no reason to change. By using the same color fo the dots in the scatter plot (i.e., for the same location) you'll add consistency and it will be easier for viewers to interpret.

linds301, 8/31/2010

Passive Infrared Counters

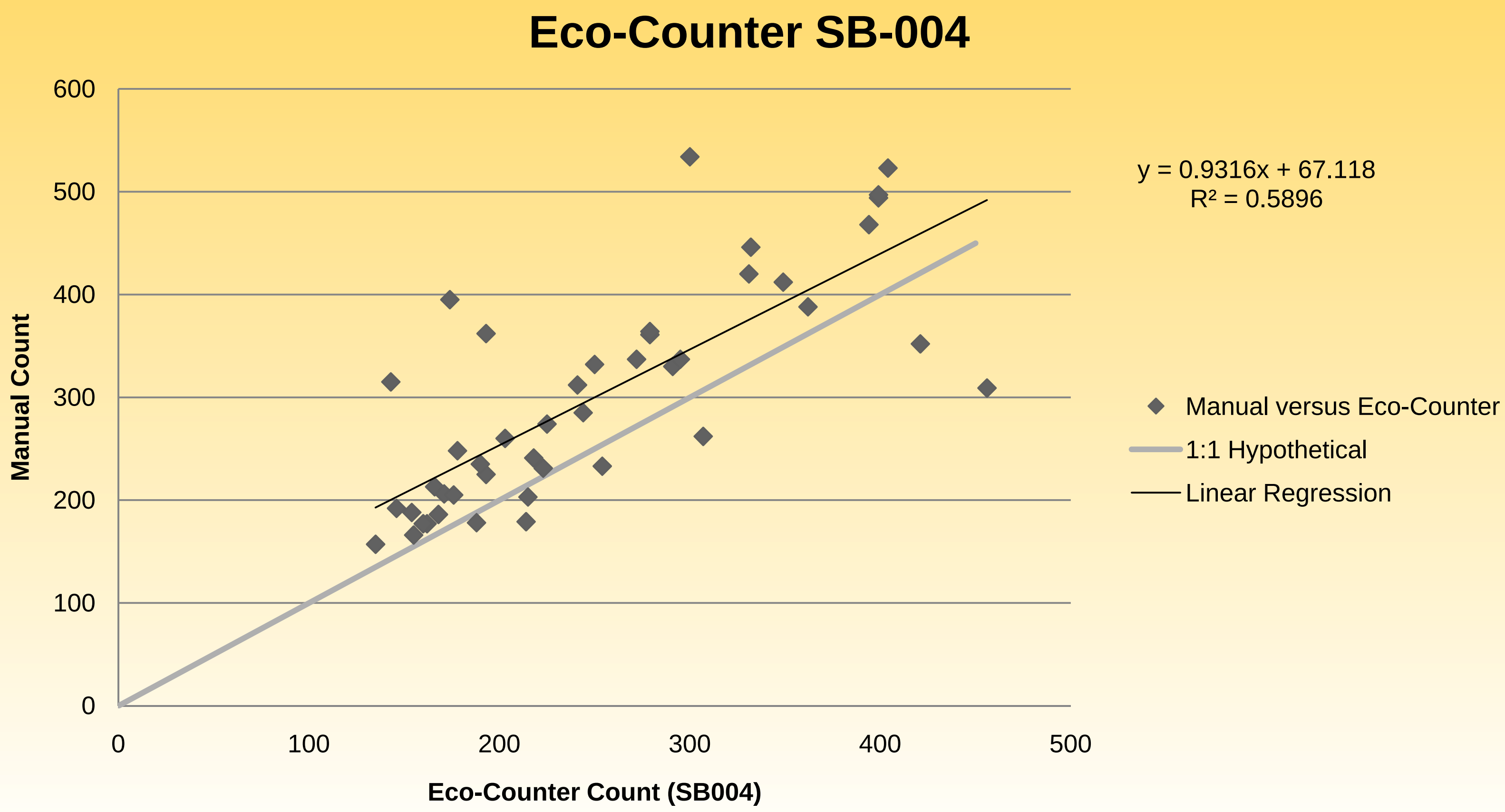
(Eco-Counter, bikes & peds)

Raw Data

	Date	Hour	SB004	SB004 OUT	SB004 IN
1	Date	Hour	SB004	SB004 OUT	SB004 IN
38	Thursday 15 Jul 2010	9:00:00 AM	33	11	22
39	Thursday 15 Jul 2010	9:15:00 AM	28	5	23
40	Thursday 15 Jul 2010	9:30:00 AM	30	7	23
41	Thursday 15 Jul 2010	9:45:00 AM	64	16	48
42	Thursday 15 Jul 2010	10:00:00 AM	43	13	30
43	Thursday 15 Jul 2010	10:15:00 AM	40	12	28
44	Thursday 15 Jul 2010	10:30:00 AM	45	9	36
45	Thursday 15 Jul 2010	10:45:00 AM	32	8	24
46	Thursday 15 Jul 2010	11:00:00 AM	30	5	25
47	Thursday 15 Jul 2010	11:15:00 AM	38	7	31
48	Thursday 15 Jul 2010	11:30:00 AM	49	11	38
49	Thursday 15 Jul 2010	11:45:00 AM	54	12	42
50	Thursday 15 Jul 2010	12:00:00 PM	47	8	39
51	Thursday 15 Jul 2010	12:15:00 PM	50	12	38
52	Thursday 15 Jul 2010	12:30:00 PM	48	9	39
53	Thursday 15 Jul 2010	12:45:00 PM	48	7	41
54	Thursday 15 Jul 2010	1:00:00 PM	43	8	35
55	Thursday 15 Jul 2010	1:15:00 PM	48	10	38
56	Thursday 15 Jul 2010	1:30:00 PM	47	7	40
57	Thursday 15 Jul 2010	1:45:00 PM	38	3	35
58	Thursday 15 Jul 2010	2:00:00 PM	40	11	29
59	Thursday 15 Jul 2010	2:15:00 PM	42	8	34
60	Thursday 15 Jul 2010	2:30:00 PM	57	6	51
61	Thursday 15 Jul 2010	2:45:00 PM	51	11	40
62	Thursday 15 Jul 2010	3:00:00 PM	68	12	56

- Detects trail users' infrared heat signatures
- Differentiates direction (i.e. left-to-right vs. right-to-left)
- Holds one year of data
- Data imported in Excel in 15-minute increments

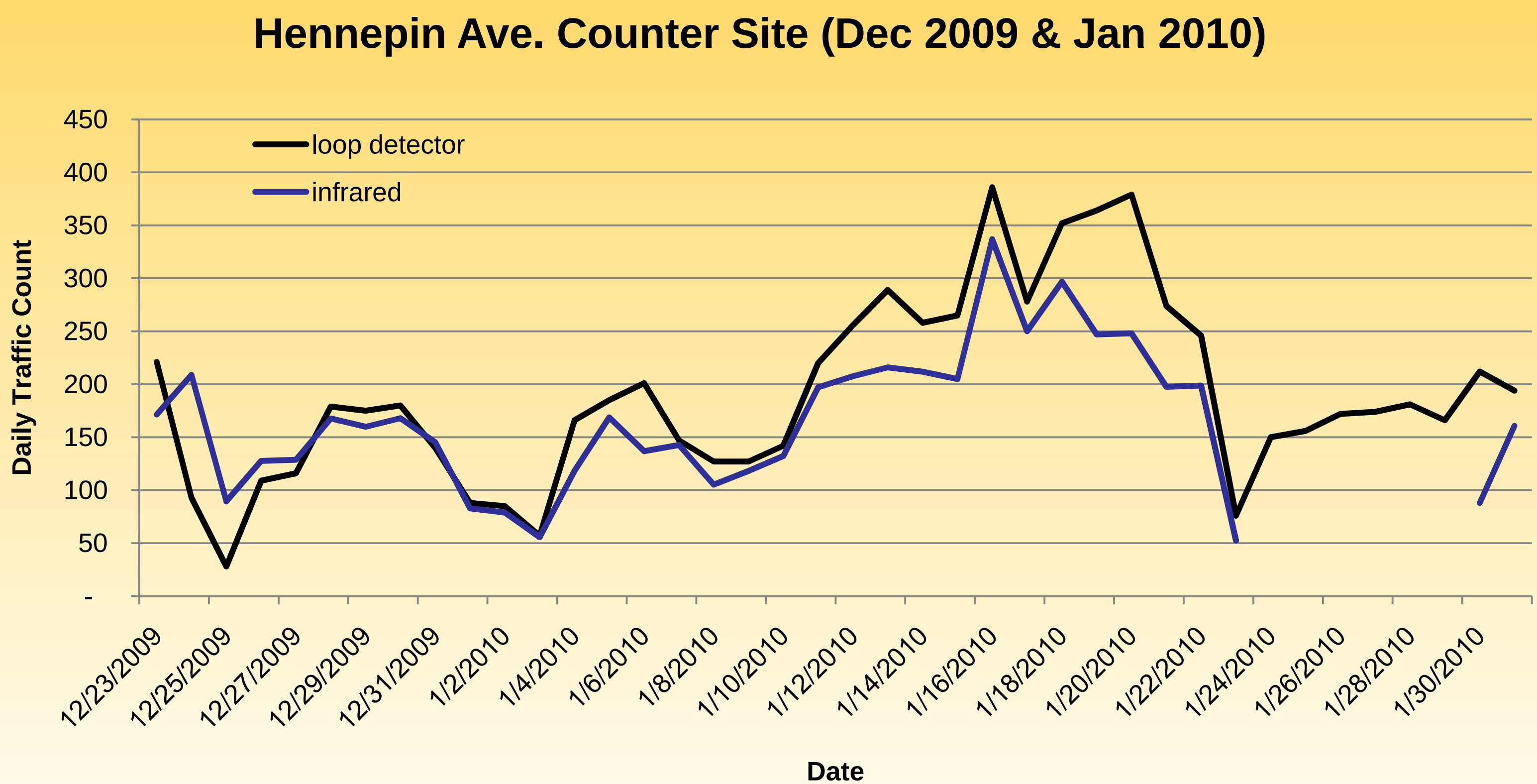
Calibrating Passive Infrared Counter



Counter Correction Equations: Variation in Adj. R^2

Counter and Unit	Bike & Ped Count	Bike & Ped Eastbound	Bike & Ped Westbound	Bike Count	Bikes Eastbound	Bikes Westbound
Magnetic Loop (Hennepin)	-	-	-	0.9806	0.9685	0.9569
Magnetic Loop (W R Parkway)	-	-	-	0.9734	0.9760	0.9335
Passive Infrared #004	0.5896	0.5365	0.2847	-	-	-
Passive Infrared # 003	0.9215	0.9227	0.1697	-	-	-
Passive Infrared #001	0.8841	0.7979	0.0723	-	-	-
Active Infrared (Hennepin)	0.9941	-	-	-	-	-
Active Infrared (W R Parkway)	0.9953	-	-	-	-	-

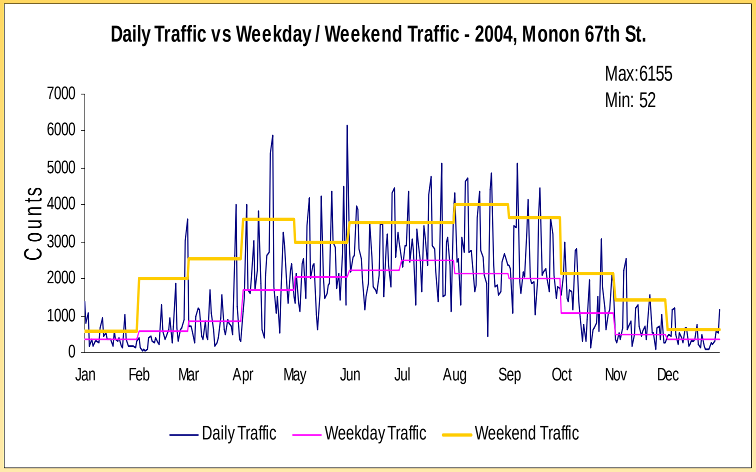
A Calibration Problem: Loop Detector Counts (bikes) > Infrared Counts (bikes & peds)

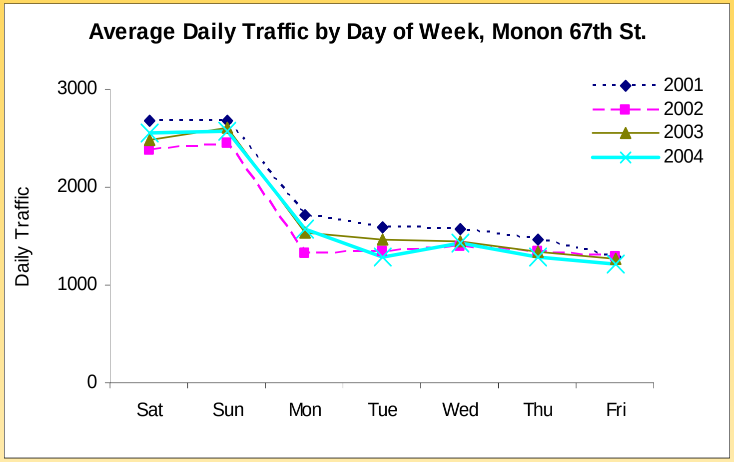


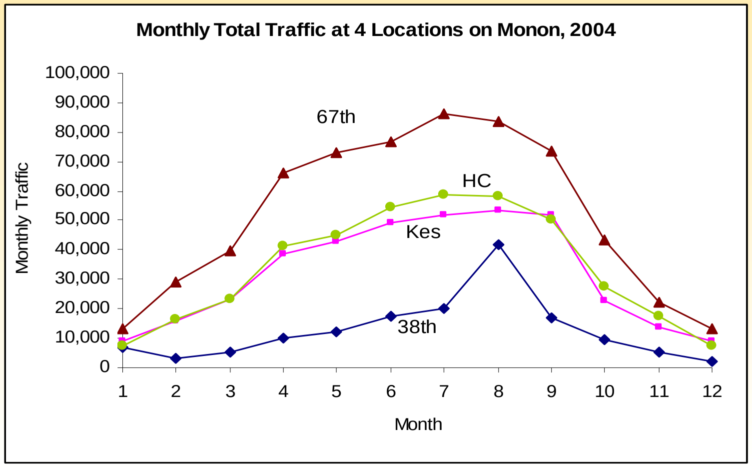
Working with Counts

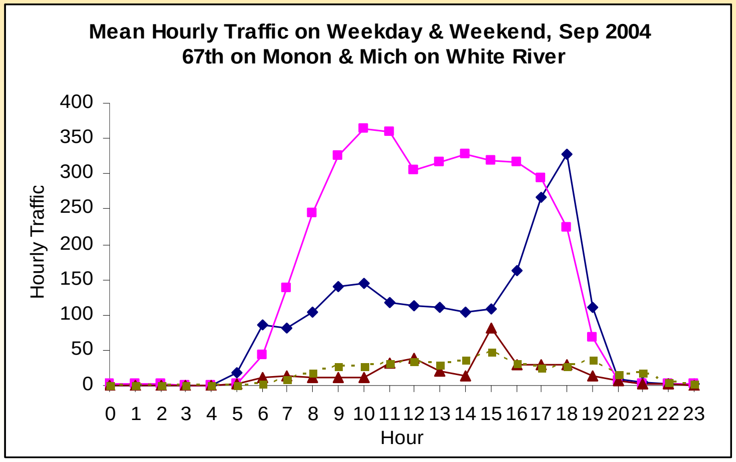
- Objective is to understand and use of patterns in data
  - Seasonality and monthly variation
  - Day of week (weekend and weekday)
  - Time of day (peak hour)
- Patterns differ by mode
  - bike vs. pedestrian
  - type of facility (on-street vs. off-street)

Temporal Patterns in Trail Traffic

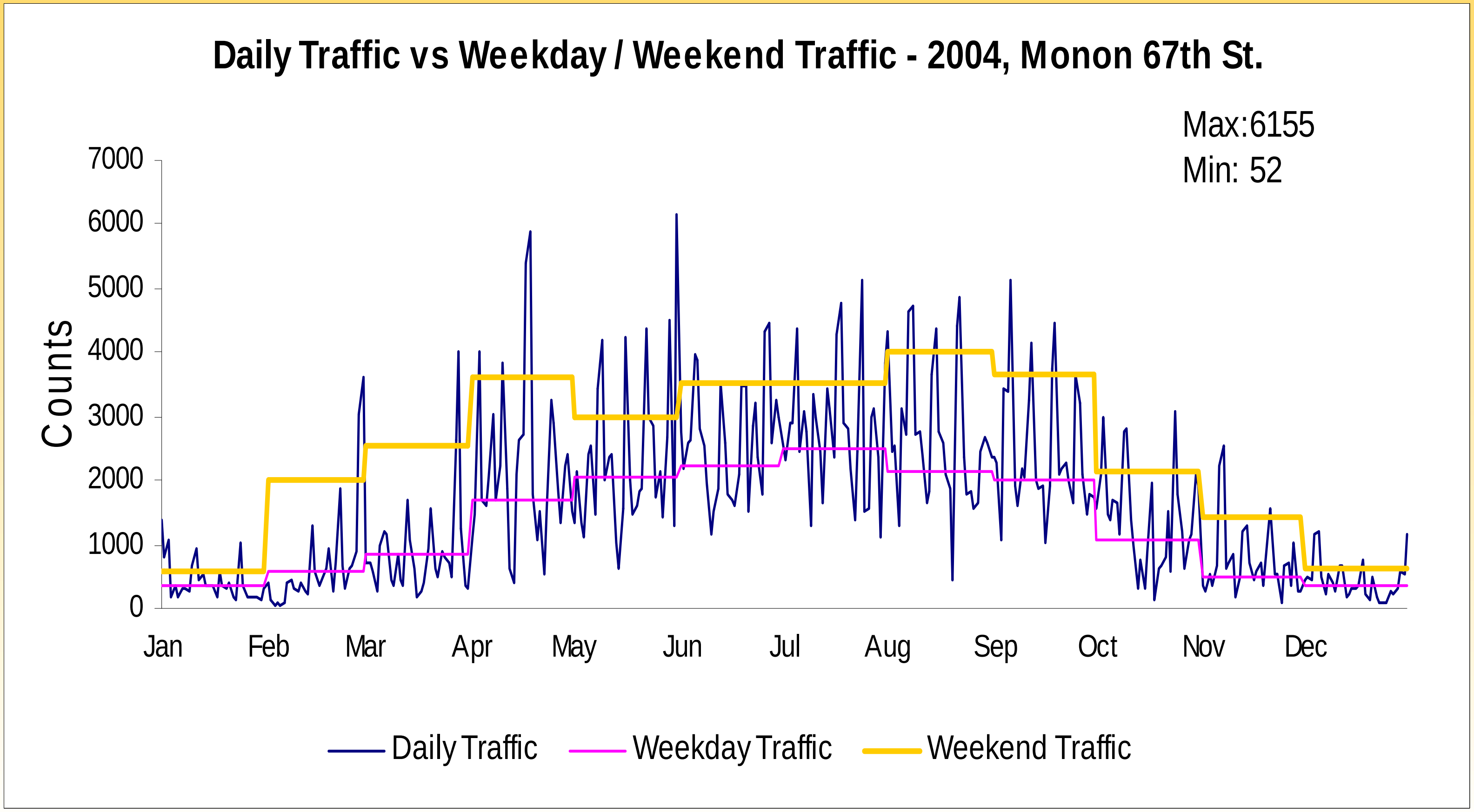






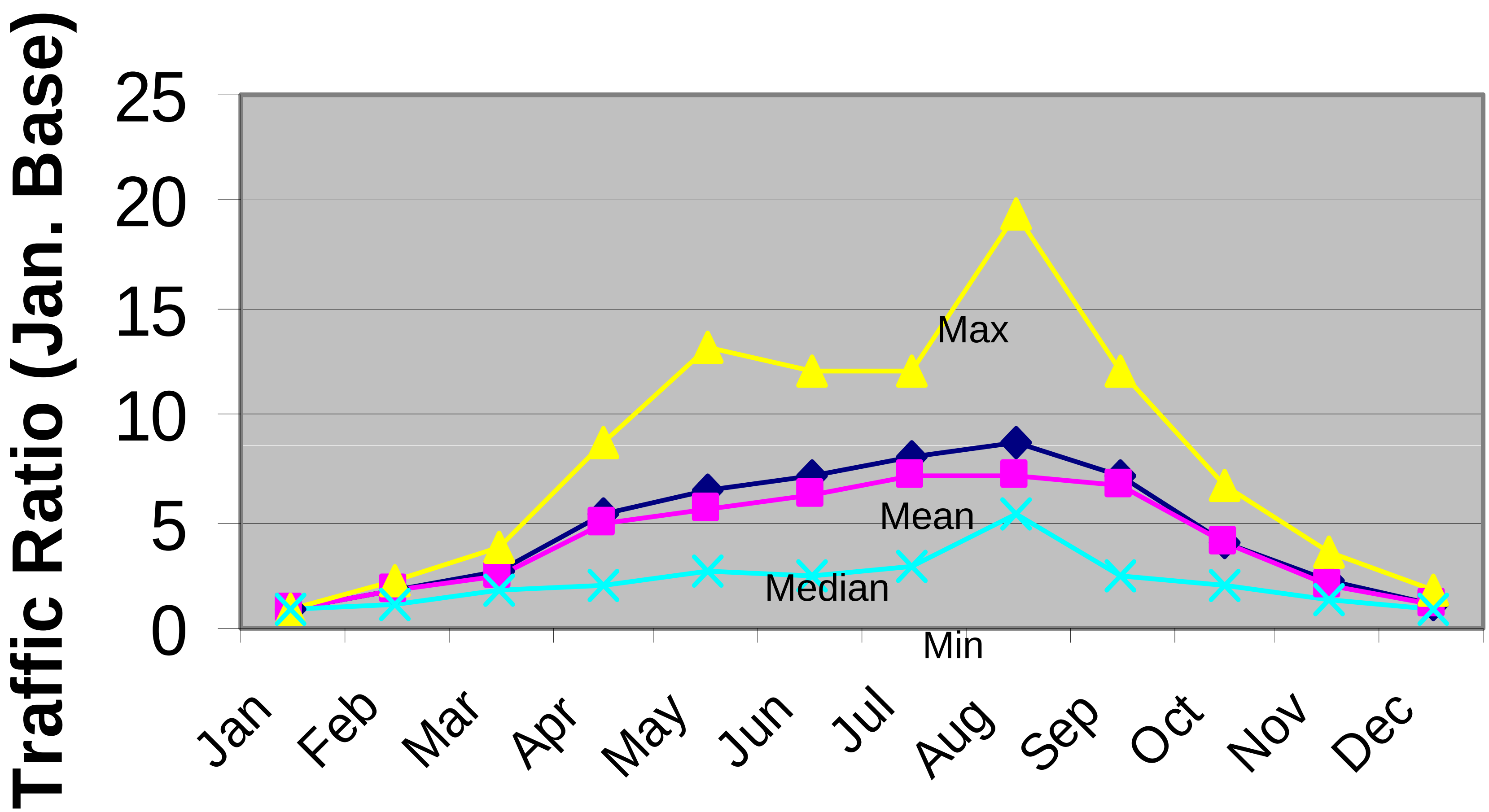


Seasonal Variation in Daily Counts
(Indianapolis, IN)

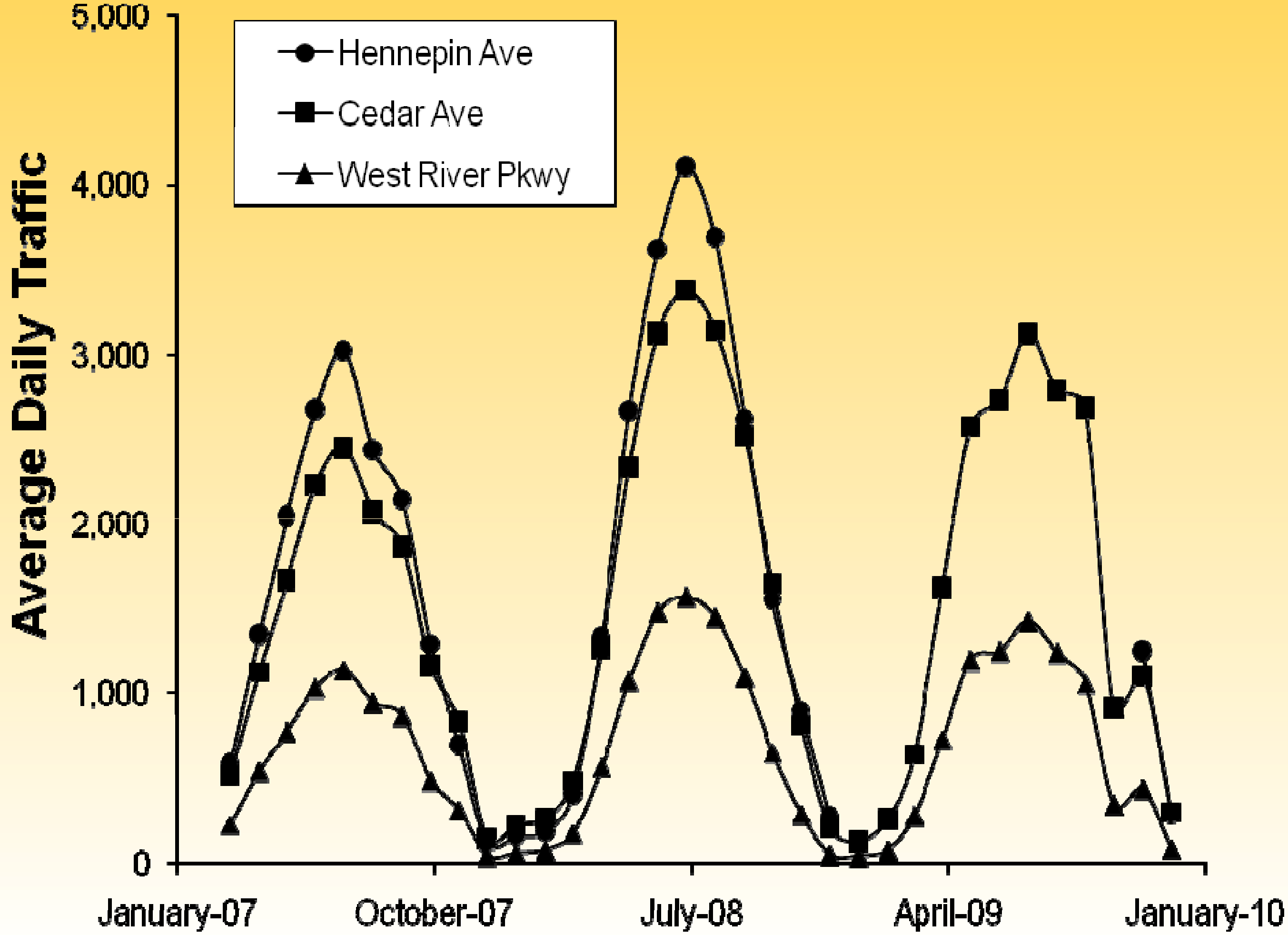


Monthly Traffic Ratios (Indianapolis)

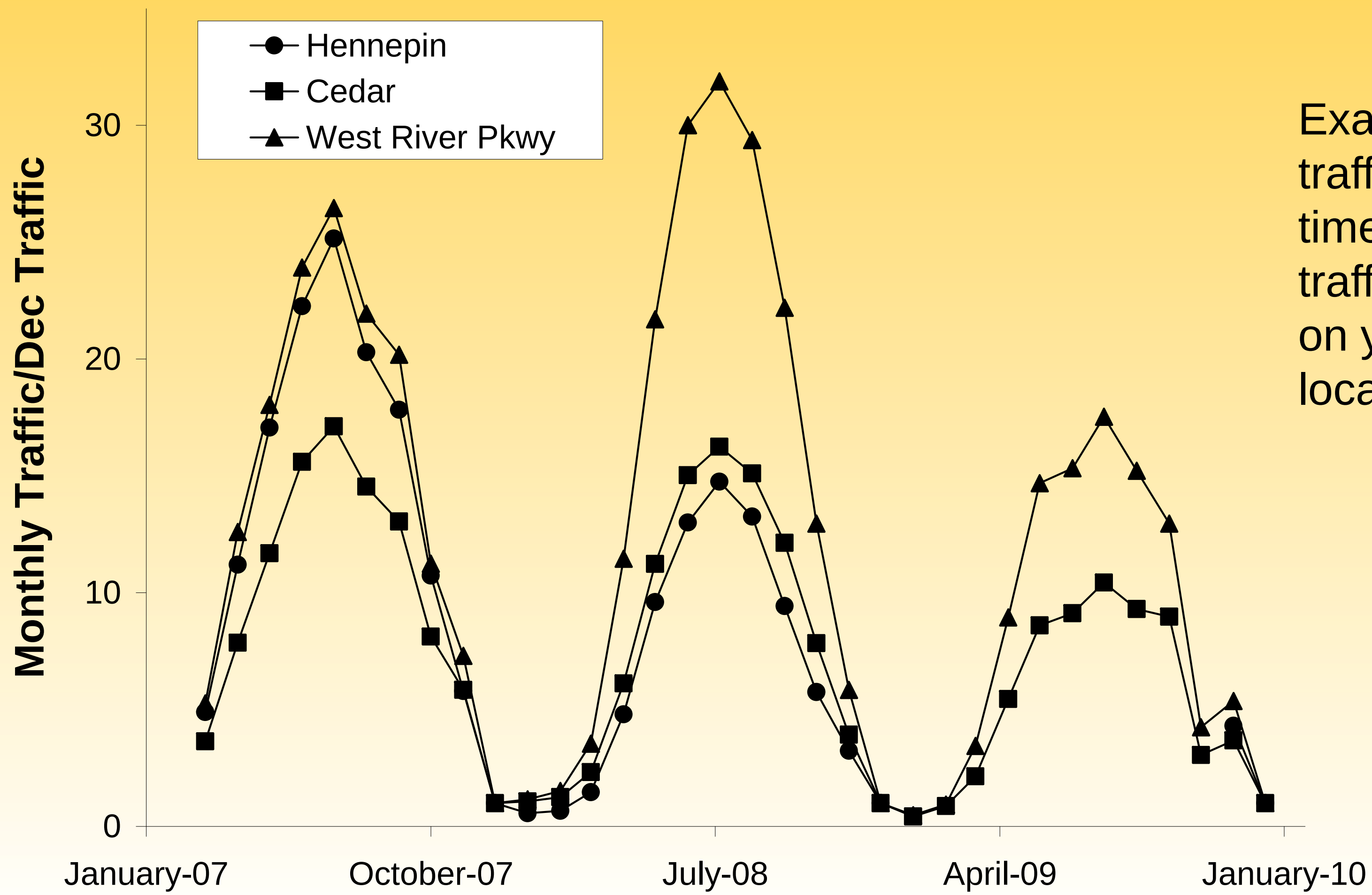
(Indianapolis, n= ± 30/month)



Mean Daily Bike Traffic Volumes
(Midtown Greenway, Minneapolis MN)

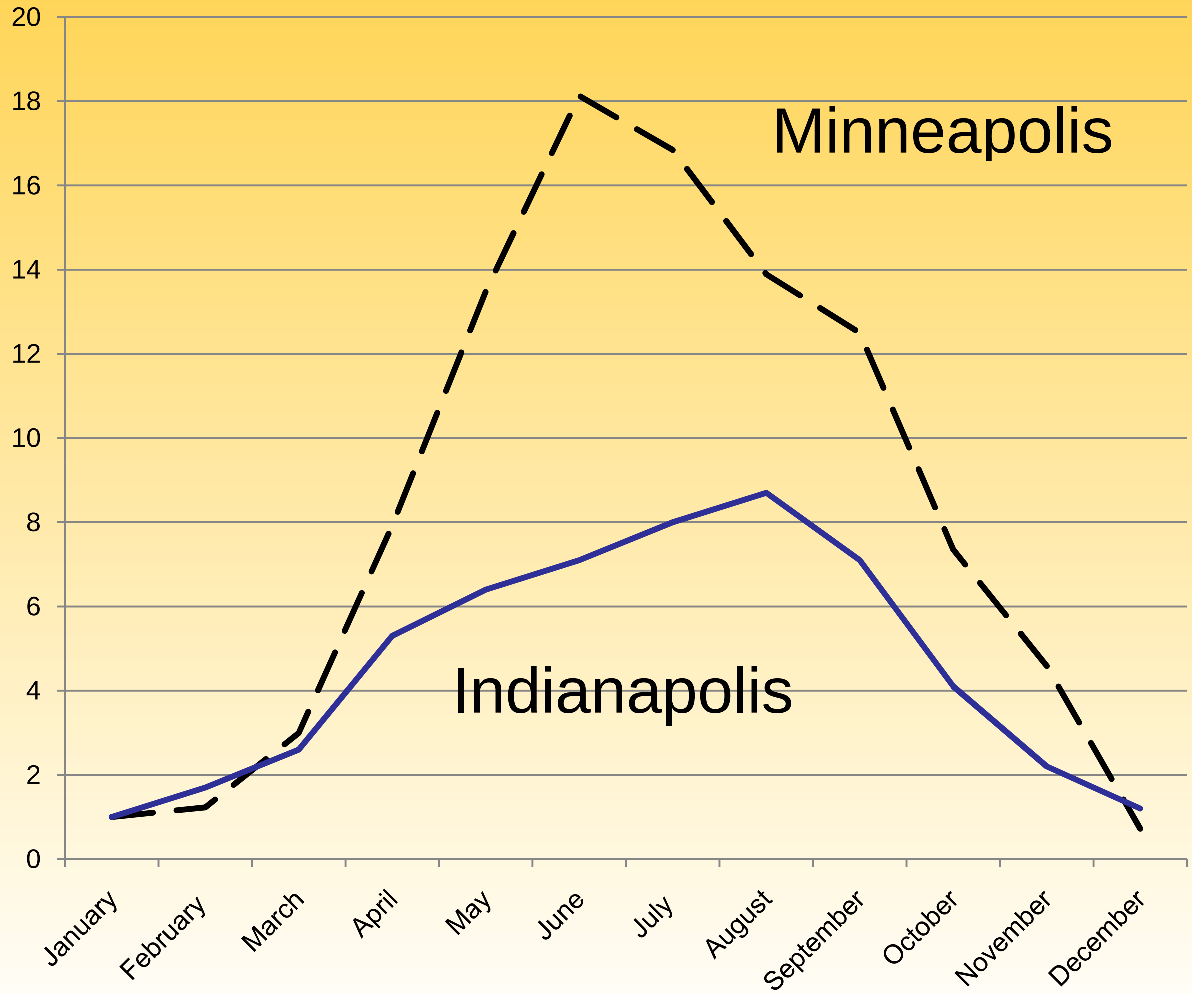


Monthly Scaling Factors
(Monthly Traffic Bike Traffic /December Bike Traffic)



Example: July traffic is 10 to 30 times December traffic depending on year and location

Monthly Traffic Ratios (scaling factors) for Greenways in Minneapolis and Indianapolis



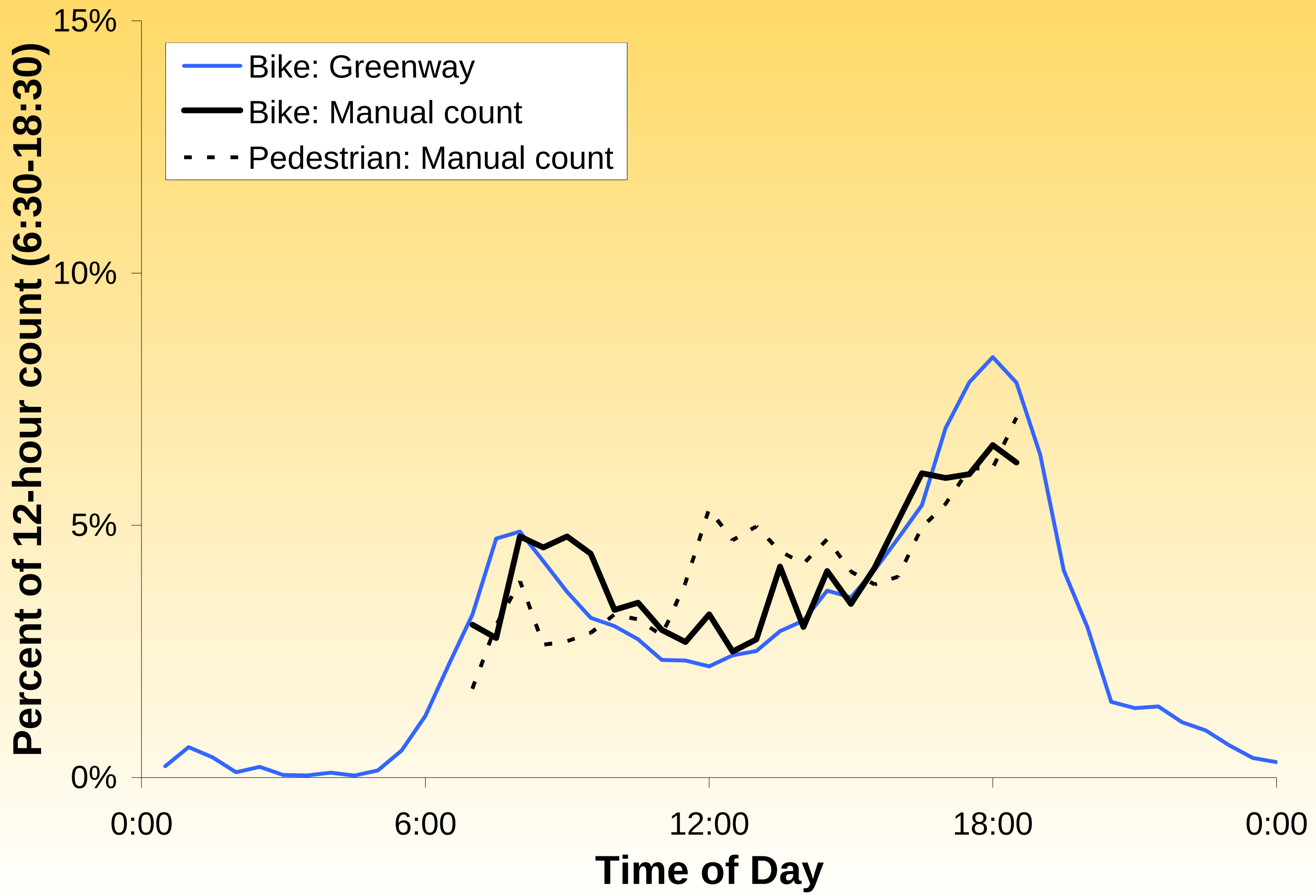
Minneapolis traffic ratios show greater seasonality.

Differences could be associated with differences in counts (bikes vs. bikes & peds) , characteristics of trails, or cultural or geographic factors.

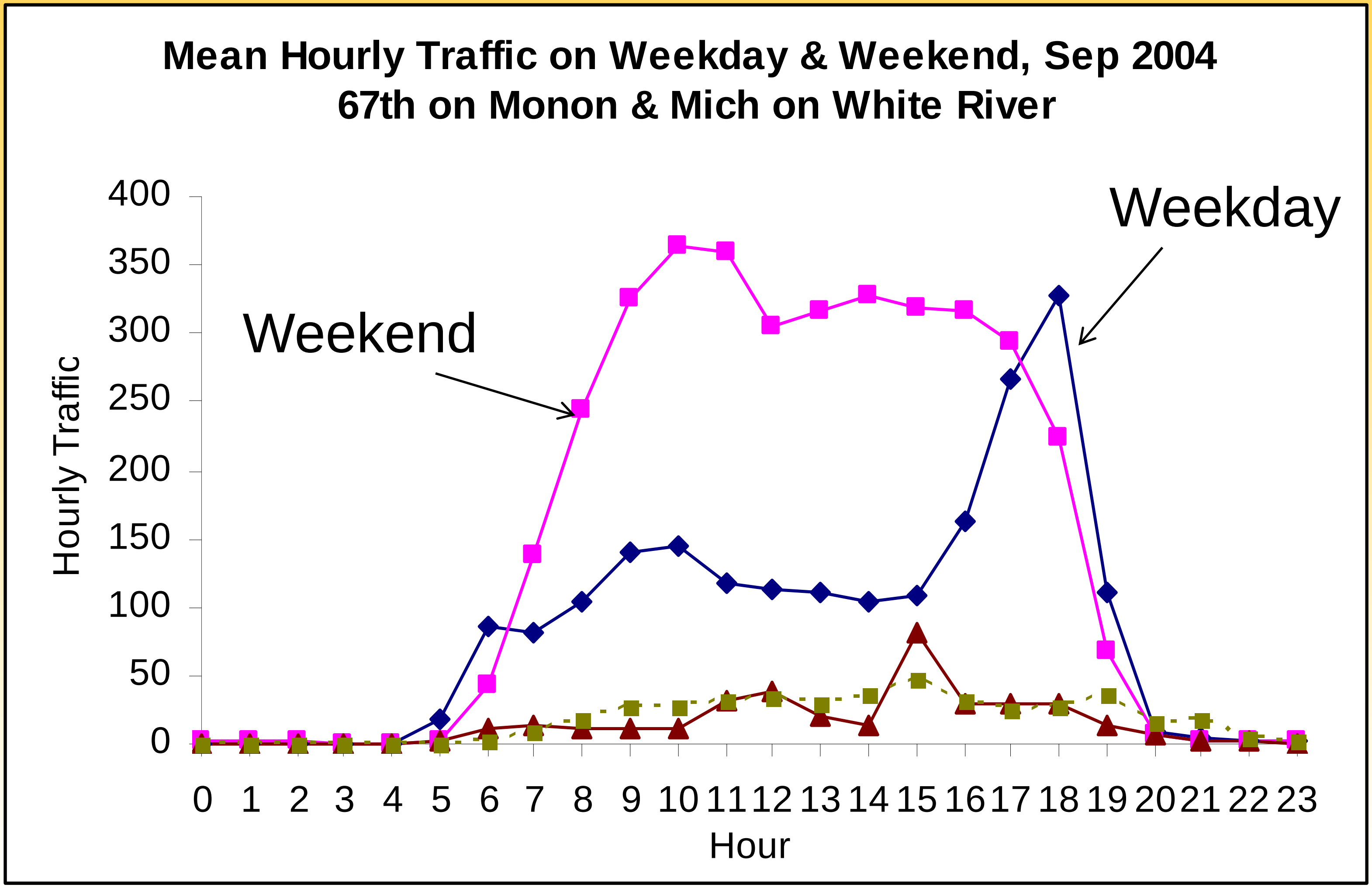
Hourly Bike & Ped Counts

- Hourly bike and ped traffic varies by
  - facility type
  - day of week (weekend-weekday)
  - season
- Weekday peak hour traffic typically occurs between 5:00 p.m. and 7:00 p.m.
- Weekend peak hour typically traffic occurs in late morning or early afternoon
- Peak hour higher for off-street facilities with more recreational use

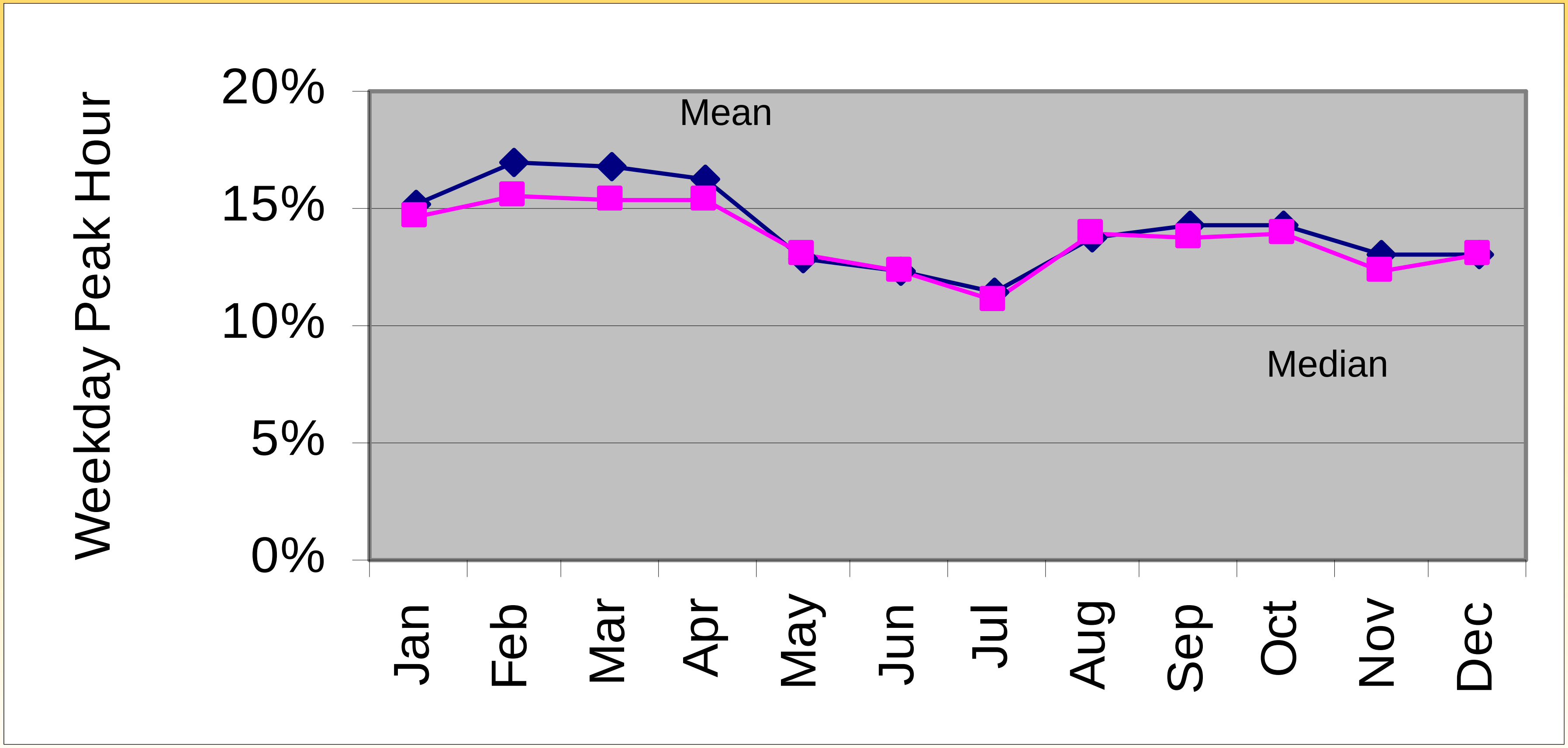
Time of Day (Hourly) Traffic Patterns Vary by Mode and Facility (Minneapolis MN)



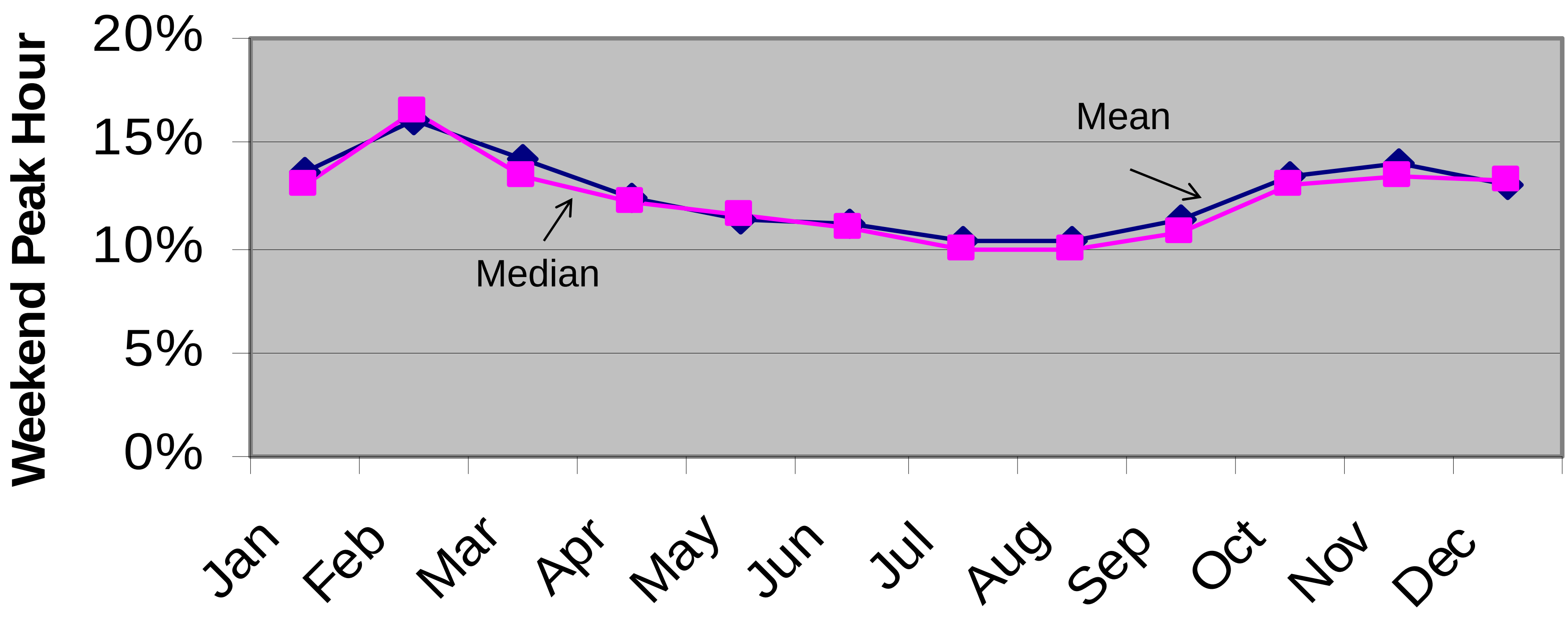
Trail Peak Hour Counts



Weekday Peak Hour Trail Traffic Varies Seasonally (11% - 17%) (Indianapolis, n=30)



Weekend Peak Hour Trail Traffic Varies Seaonally (10% - 16%) (Indianapolis, n=30)



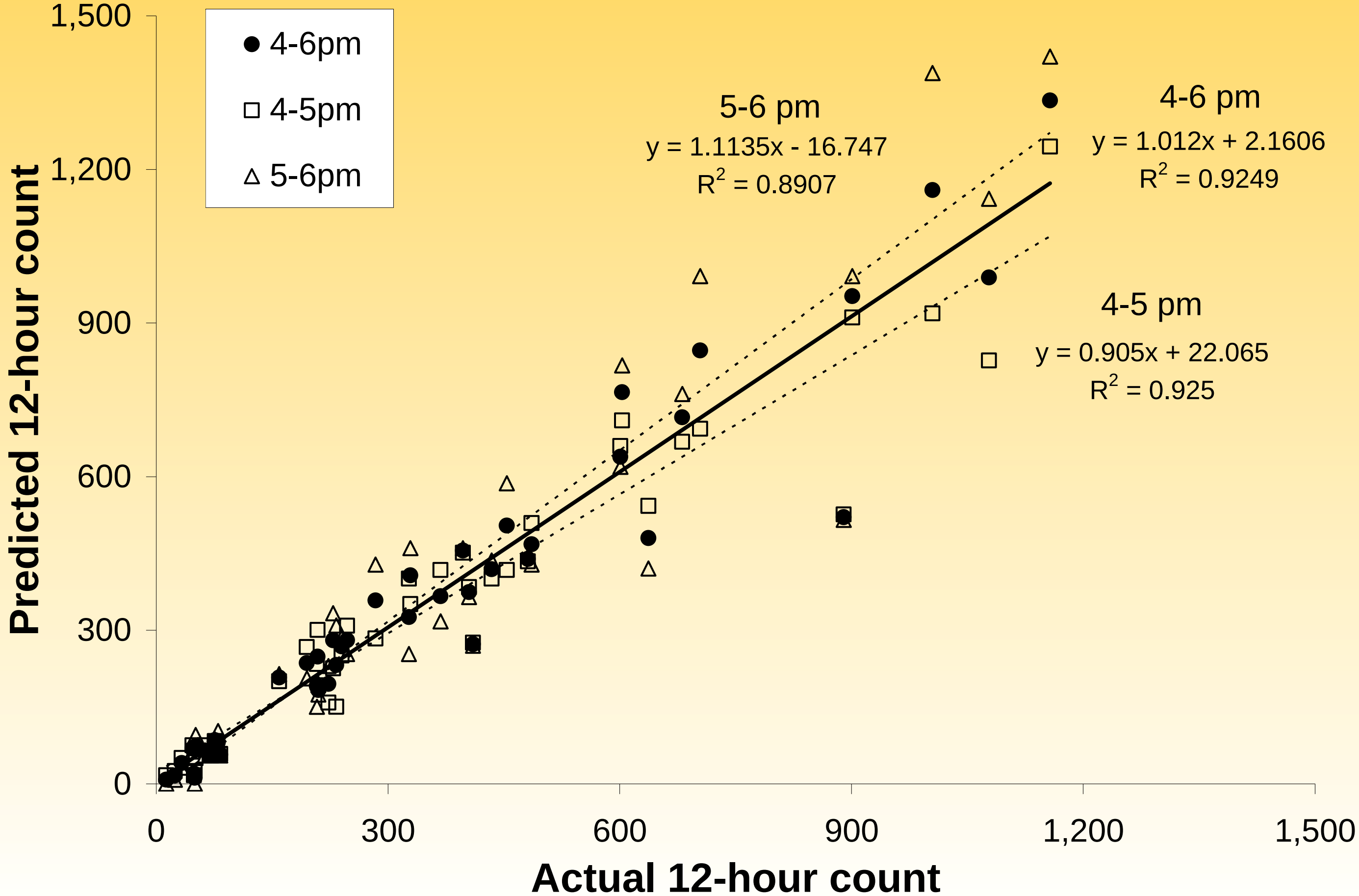
Hourly Adjustment Factors: 12-Hour On-street Traffic Volumes (Minneapolis MN)

Time period	Bicycle			Pedestrian		
	Percent of 12-hour count	Adj. factor	R^2	Percent of 12-hour count	Adj. factor	R^2
7-8am	7.5%	13.2	0.88	6.9%	14.5	0.91
8-9am	9.3%	10.7	0.90	5.3%	18.7	0.96
9-10am	7.8%	12.9	0.89	6.1%	16.4	0.97
10-11am	6.4%	15.6	0.89	5.9%	16.8	0.96
11-noon	5.9%	16.9	0.87	9.2%	10.9	0.99
noon-1pm	5.2%	19.1	0.77	9.7%	10.3	0.99
1-2pm	7.2%	14.0	0.88	8.7%	11.5	0.99
2-3pm	7.5%	13.3	0.84	8.8%	11.4	0.98
3-4pm	9.3%	10.8	0.90	7.8%	12.8	0.98
4-5pm	**12.0%**	**8.4**	**0.93**	10.4%	9.6	0.97
5-6pm	12.6%	7.9	0.89	**12.3%**	**8.2**	**0.996**

Example:

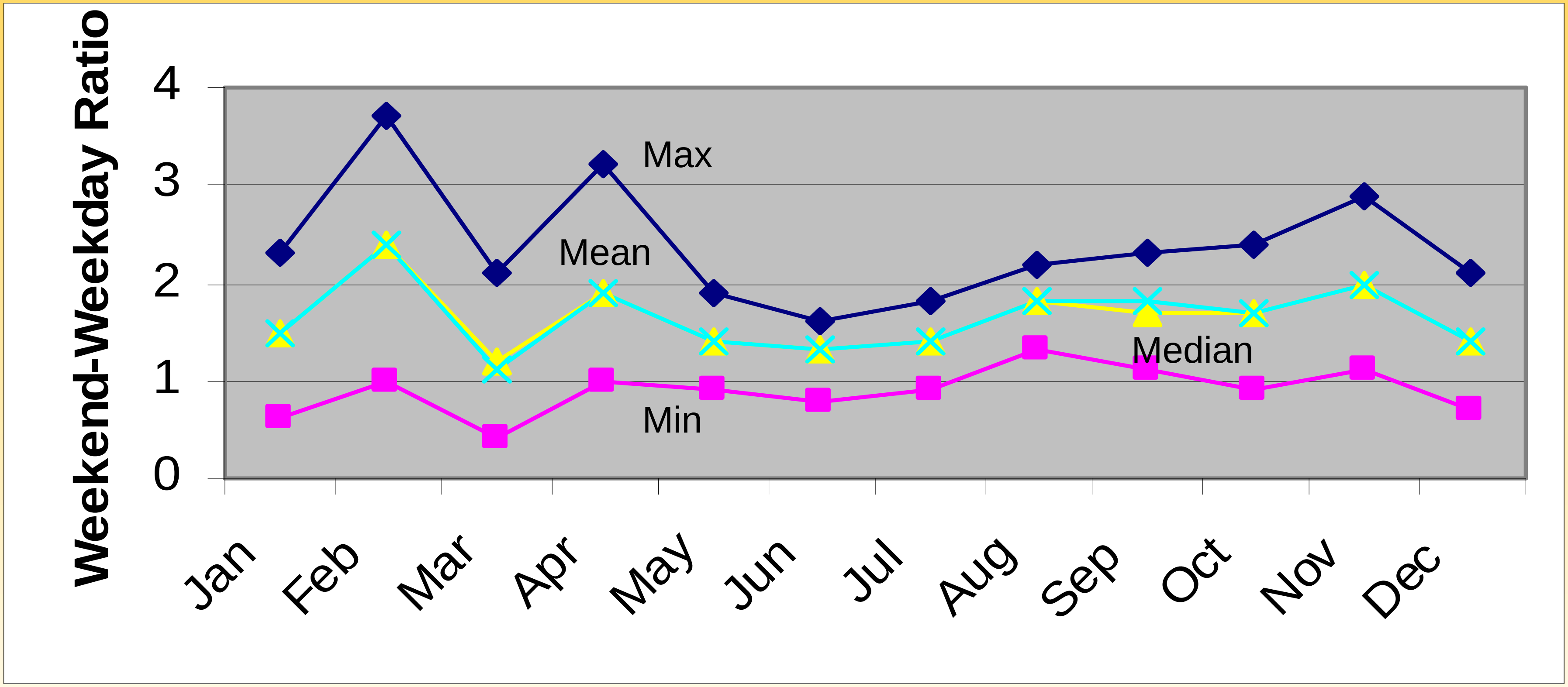
Multiplying 4-5 pm traffic by 8.4 yields 12-hour traffic volume.

Estimated 12-hour Bike Traffic Highly Correlated with Actual 12-hour Traffic



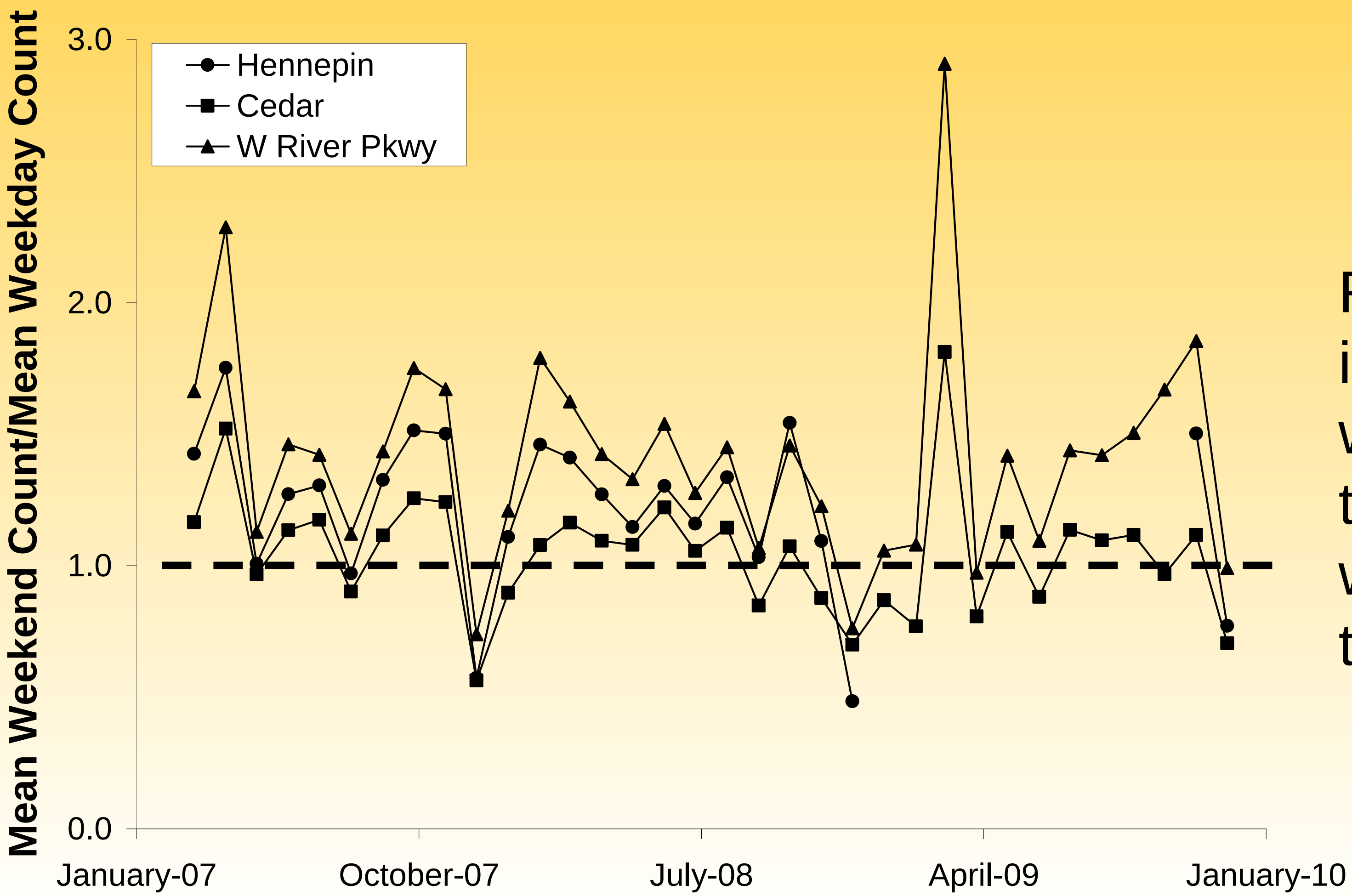
Weekend-Weekday Trail Traffic Ratios (bikes&

(bikes & peds; Indianapolis, n=30)



Weekend-Weekday Trail Traffic Ratios

(bikes; Minneapolis)



Ratios > 1 indicate mean weekend traffic > mean weekday traffic

Using Traffic Ratios to Extrapolate

1. Sample trail traffic during weekday peak hour
2. Use peak hour proportions to estimate weekday daily traffic
3. Use weekend-weekday traffic ratios to estimate weekend daily traffic
4. Aggregate daily estimates to obtain monthly traffic;
5. Use monthly traffic ratios to estimate traffic for other months and annual traffic; and
6. Impute annual visits from annual traffic.

- Example: Using mean peak hour traffic 9/12-9/16 to estimate monthly and annual traffic

Monthly and Annual Traffic Estimates (Monon Trail with site (M67) and median ratios)			
	Counter (actual)	**M67 ratios (% error)**	**Median ratio (% error)*****
• Weekday mean peak hour traffic	255		
• Weekday average estimate	1,534	1,567 (2.1%)	1,851 (20.7%)
• Weekend Day Traffic	--	2,820	2,961
• Monthly Traffic	68,647	57,035 (-16.9%)	64,406 (-6.2%)
• Annual Traffic	606,906	471,067 (-22.4%)	484,489 (-20.2%)

A Conceptual Model of Trail Use

For individual i living in zone j,

$P_{ijkl} = f(C_i, R_j, S_k, D_{jk}, T_{kl})$

P_{ijkl} = probability of individual i in zone j traveling to access point k and then using the trail to destination l.

C_i = characteristics of individual i

R_j = characteristics of area j

S_k = characteristics of access points k

D_{jk} = distance and other characteristics of trip from j to k

T_{kl} = characteristics of trail from k to l

Modeling Multiuse Trail Traffic

Primary Aims

1. Establish objective measures of urban trail traffic
2. Identify correlates of trail traffic
3. Explain and predict spatial variation in trail traffic

The General Approach (Indianapolis)

- Model traffic on facility (not individuals)
  - Observe trail traffic in field
  - Monitor trail traffic with infrared counters
  - Collect secondary data
  - Measure neighborhood and trail characteristics using remote sensing and GIS
  - Estimate statistical models

Traffic Counts: Infrared Counters

- 30 locations in diverse neighborhoods on a five trail, 33 mile network
  - 4 locations: November 2000 – December 2005
  - 2 locations: September 2002 - December 2005
  - 24 locations: May 2004 – December 2005
- Analyses
  - 18,142 daily counts (92.7% of days through 7/05)
  - 24,177 through 12/05

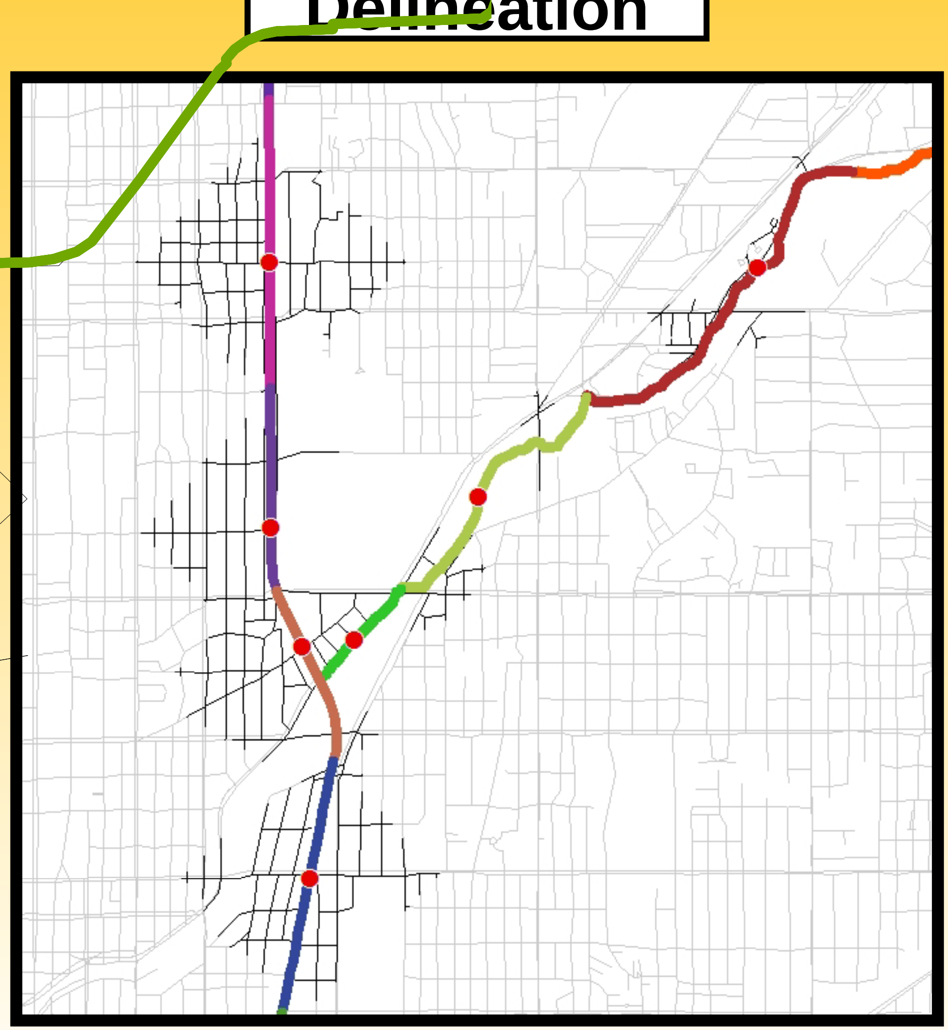
Models of Trail Traffic

- Trail traffic modeled as function of
  - Day of week
  - Month of year
  - Daily weather (temperature, precipitation, sunshine, snow: deviations from normal)
  - Neighborhood socio-demographics
  - Neighborhood urban form
  - Trail characteristics including viewsheds
- Socio-demographic and urban form variables measured for neighborhoods along trail or pedestrian access zones
- Models explain > 80% of variation in daily trail traffic (bikes & peds)

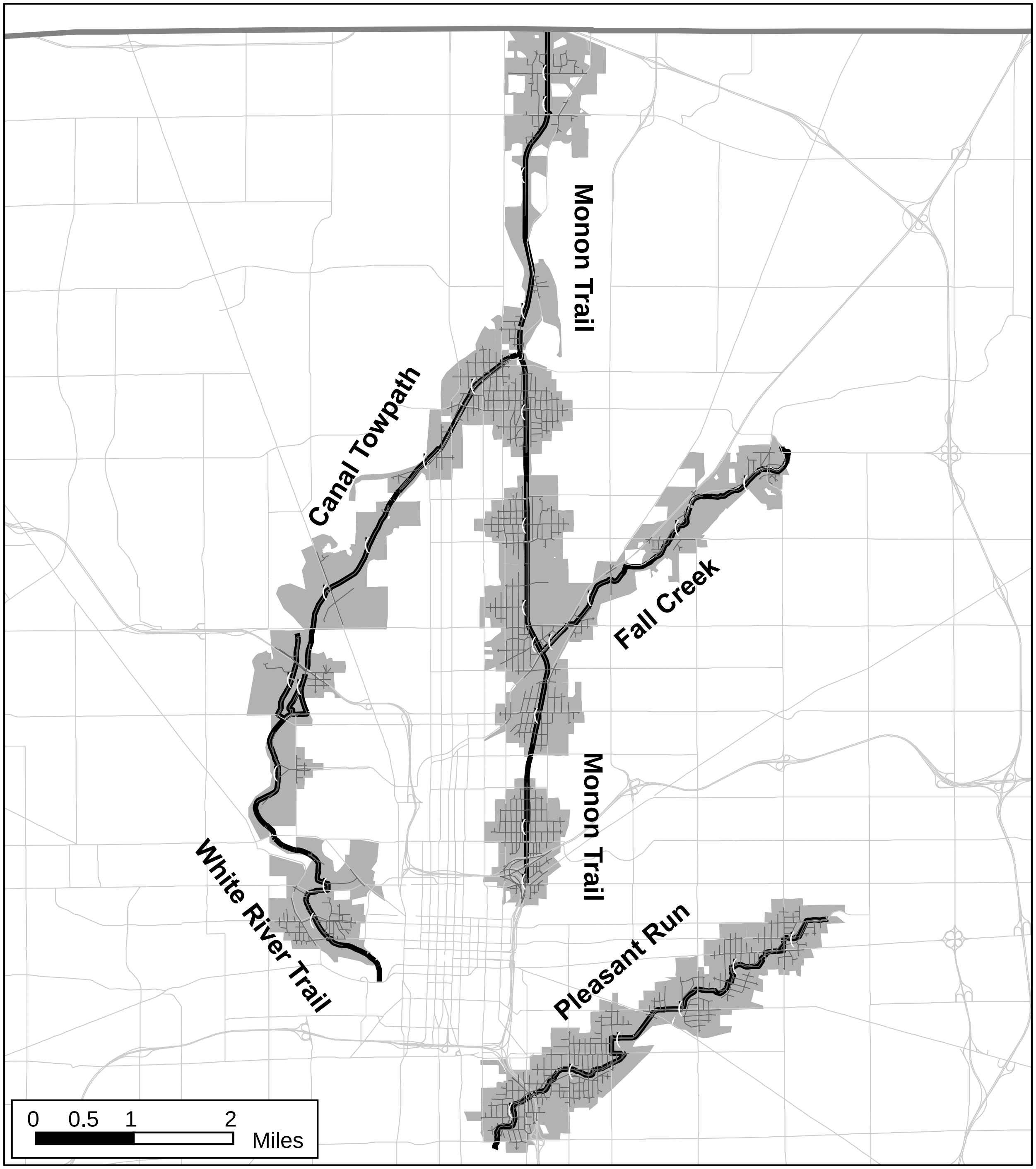
Neighborhood Delineation

½ Mile Route
Monitor
Roads
Trail

Segment Delineation



Trail Segments
½ Mile Routes
Monitor



Trail Monitor Neighborhoods

- Pedestrian access zones or catchments
- Defined by ½ mile street network from monitor locations
- Census data aggregated for neighborhood socio-demographic characteristics

Greenways

! Counter Locations

Counter Neighborhoods

Major Roads

Counter Networks (1/2 mile)

Marion County Boundary

Correlates of Trail Traffic (controls)

Temporal	Hypothetical Effect	Measured Effect
Weekend	positive	positive
Jan – Nov	positive	positive
StateFair	positive	positive
Weather		
Temperature deviation from normal (squared term)	positive	positive
Precipitation deviation from normal	negative	negative
Snow deviation from normal	negative	negative
Sunshine deviation from normal	positive	positive

Neighborhood Variables

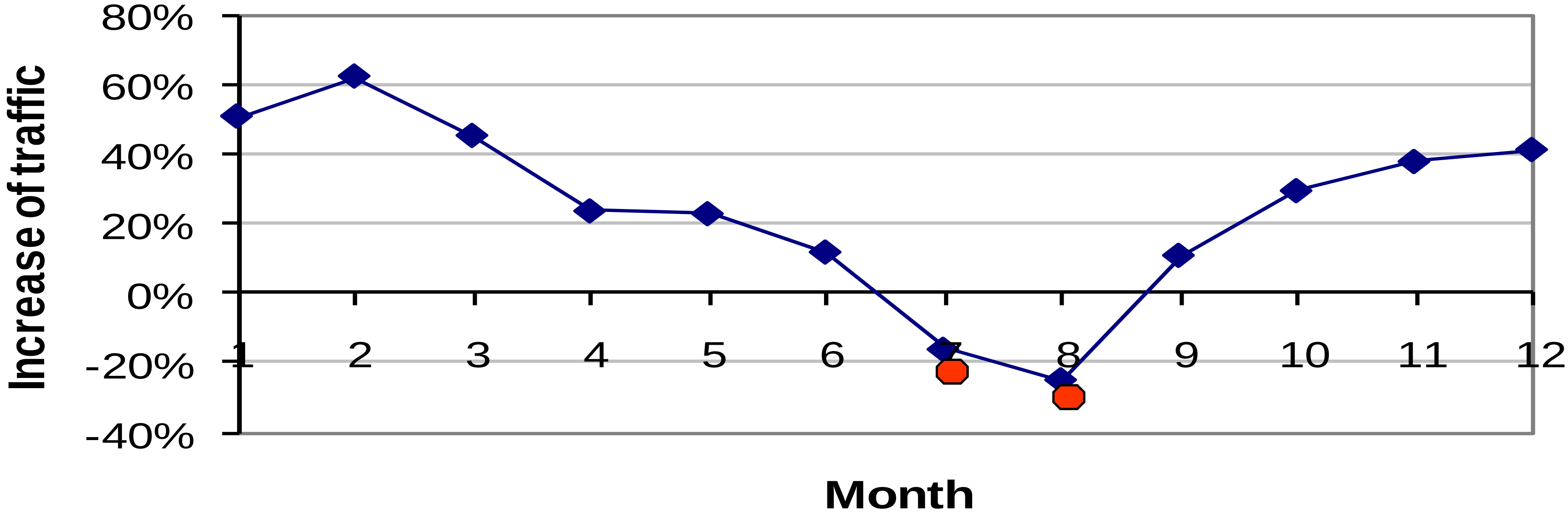
Socio-demographics Characteristics	Hypothetical Effect	Measured Effect
% Population less than 5 and greater than 64	negative	negative
% African American	negative	depends on model
% other ethnicity, exclude White and African American	negative	depends on model
Mean % Population 25+ with College Degree	positive	positive
Mean Median Household Income, in dollars	positive	positive
Urban Form		
Population density in 1/2 mile network distance to monitor	positive	positive
Percentage of commercial land use in trail neighborhood	positive	positive
Parking lots (Square Feet) in trail neighborhood	positive	positive
Average length of network street segments within 1/2 mile of counter;	negative	positive

Trail Segment Characteristics

Description of Trail Segment Characteristics	Hypothetical Effect	Measured Effect
Openness: Percent total area visible within ½ mile of trail segment	positive	positive
Interconnectedness: Average value of visual magnitude for segment	positive	positive
Land Use Diversity: Shannon's Diversity Index of land use in viewshed	positive	positive
Greenness: Difference between mean NDVI in neighborhood and trail viewshed	positive	positive
Percent Not Paved: Percent trail length with non-paved surface (e.g., gravel)	negative	negative
Railroad Xing: Number of railroad crossings at grade	negative	negative
Trail Intersection	positive	negative
Amenity Density: Number art, bench, signs divided by segment length	positive	positive
Average slope along trail segments	?	depends on model
Sinuosity of trail segment	? (positive for nature trails)	depends on model
Road Xing Density: Segment length / number of road crossings at grade	negative (interrupts use) positive (access)	depends on model

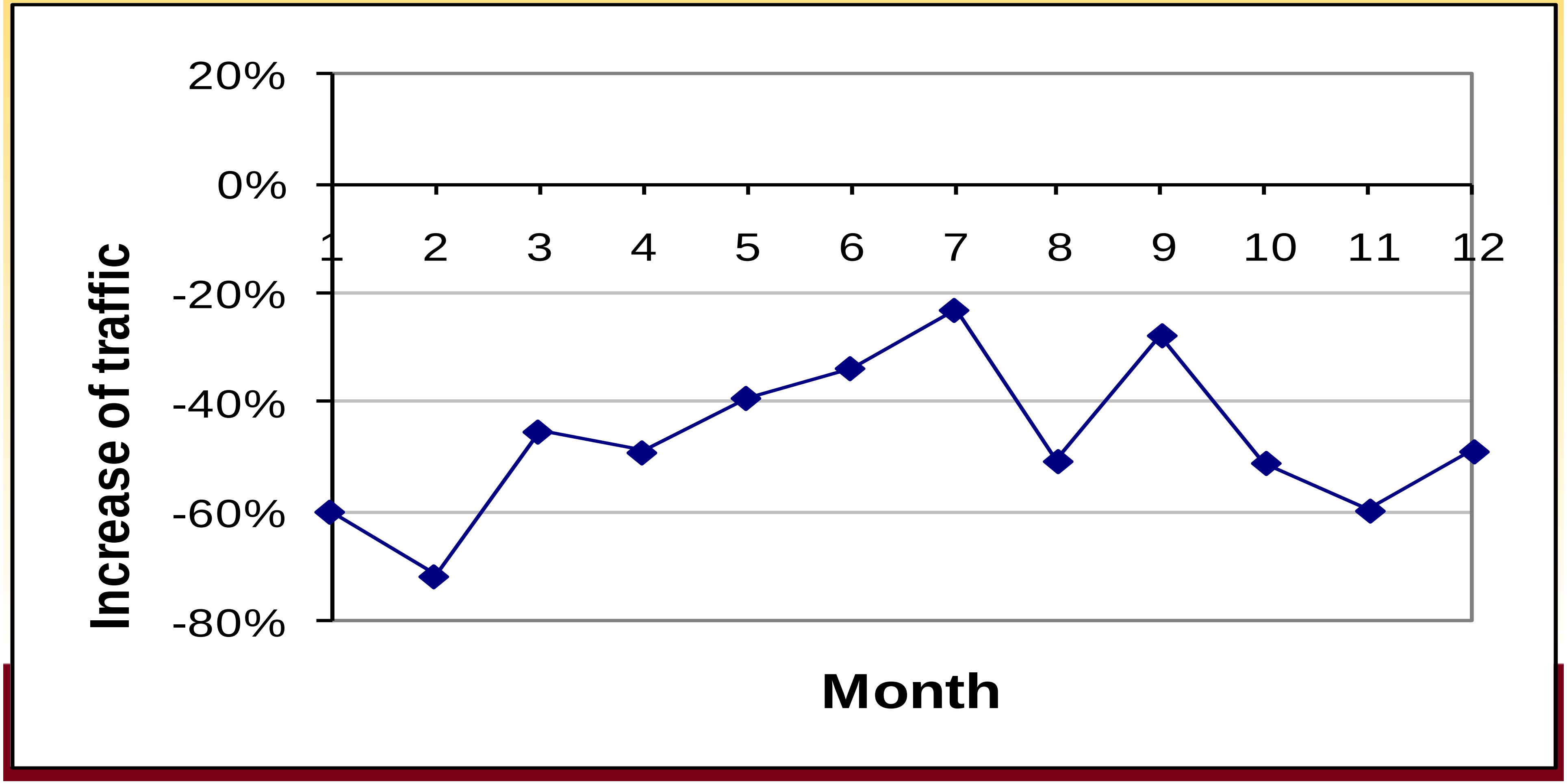
Effect of Temperature Varies Seasonally

- Temperature 10F > daily average correlated with significant change in daily trail traffic



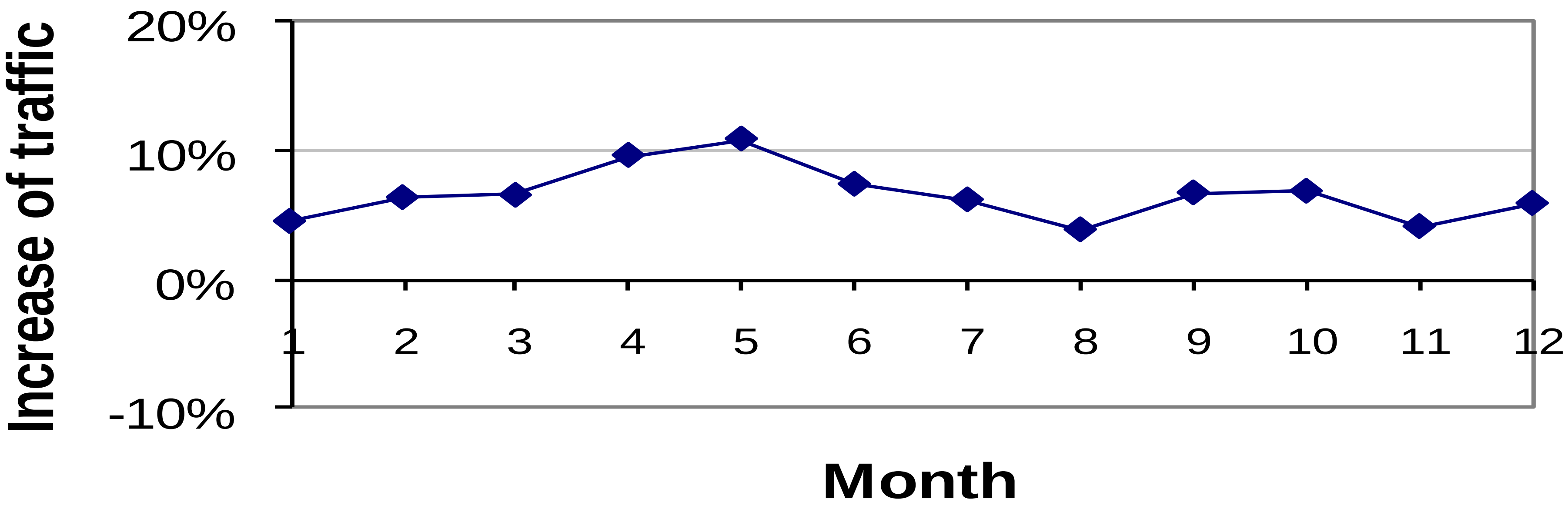
Effect of Precipitation Varies Seasonally

- Precipitation 1 inch > daily average correlated with significant drop in daily trail traffic



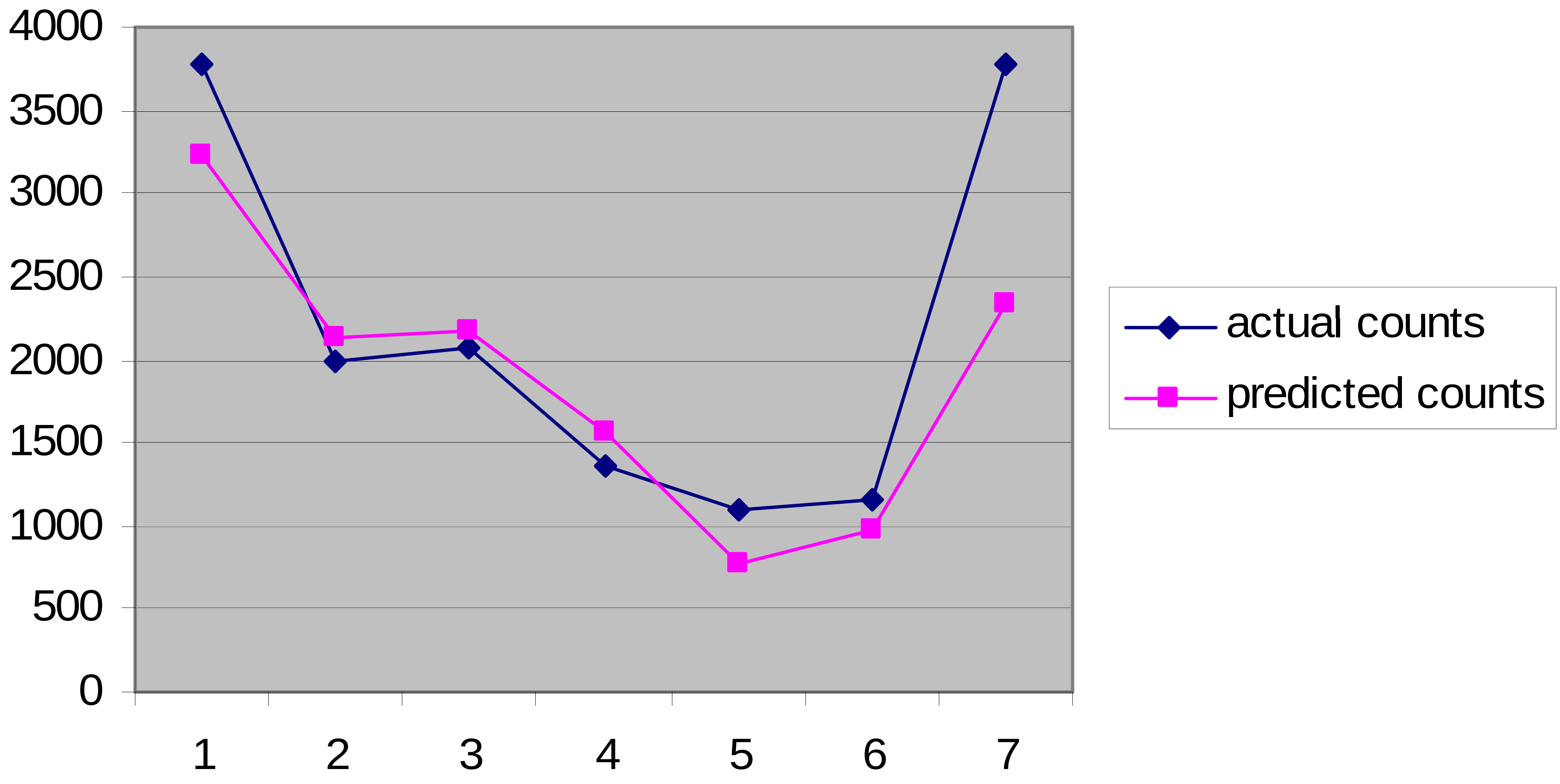
Effect of Sunshine Varies Seasonally

- Sunshine 10% > daily average correlated with significant increase in daily trail traffic



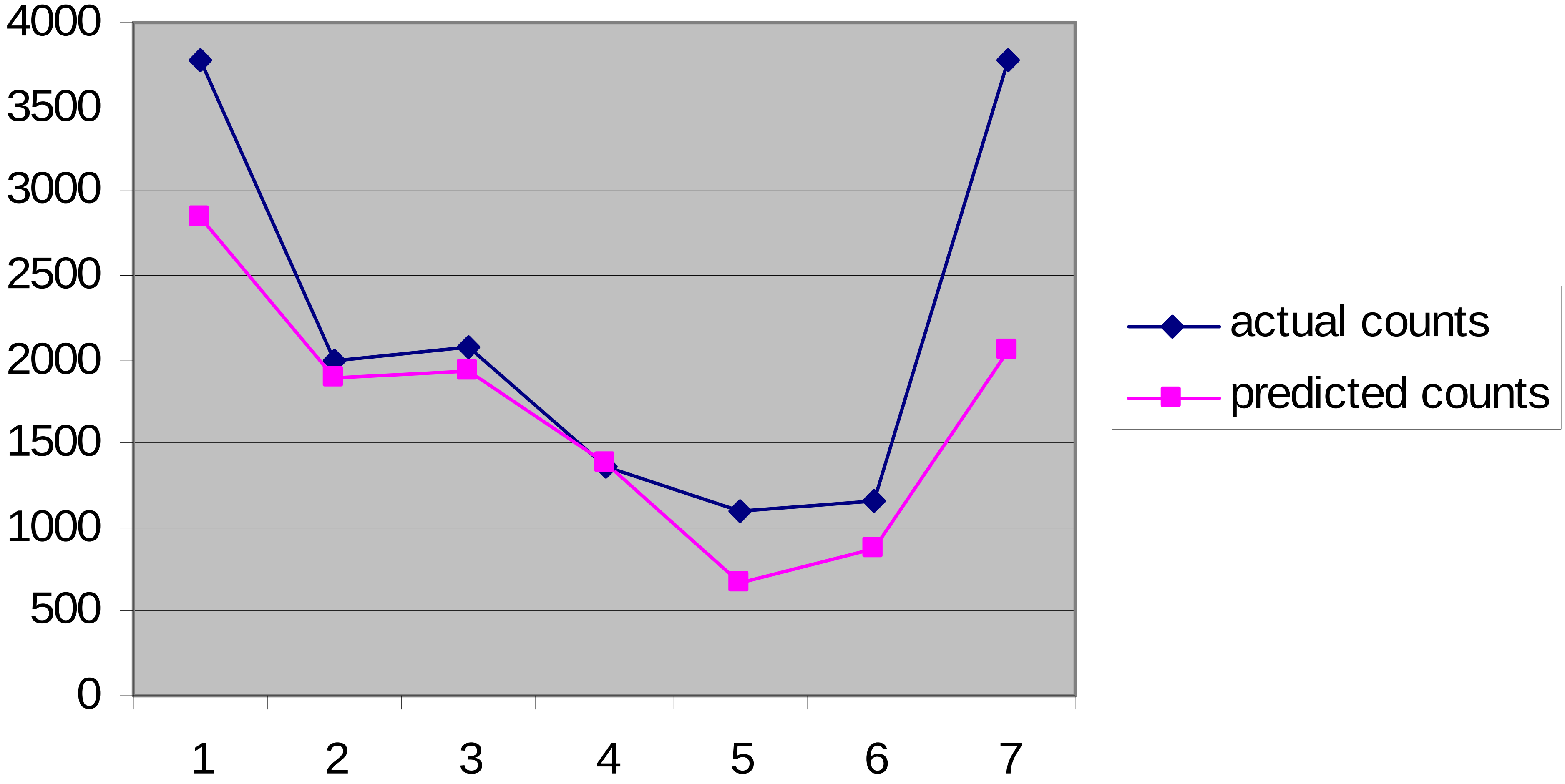
Model with Neighborhood Access Zones: Predicted & Actual Traffic

Monon Trail (M67 Site), 9/11-9/17



Tract Model (no urban form variables) Predicted and Actual Traffic

(Monon Trail (M67) Site, 9/11-9/17)



Model Error in Traffic Estimates: Ranges from 18% - 39%

		Best Model		Tract Model	
	Mean Actual Daily Traffic	Mean Predicted Daily Traffic	Error (%)	Mean Predicted Daily Traffic	Error (%)
M67 Site	2176	1771	-18.2	1674	-20.7
PLR3 Site	136	104	-25.1	164	-39.2

Predicting Bike & Ped Traffic on Streets & Sidewalks (Minneapolis)

- 12-hour traffic volume = f(
  - Daily weather (temperature, deviation from average temperature, precipitation, wind speed)
  - Neighborhood characteristics and form (population age, income, education, race, population density, land use mix, employment accessibility, crime)
  - Traffic infrastructure type (street type, presence of bike facility, type of bike facility)
  - Other factors (variables to be added)

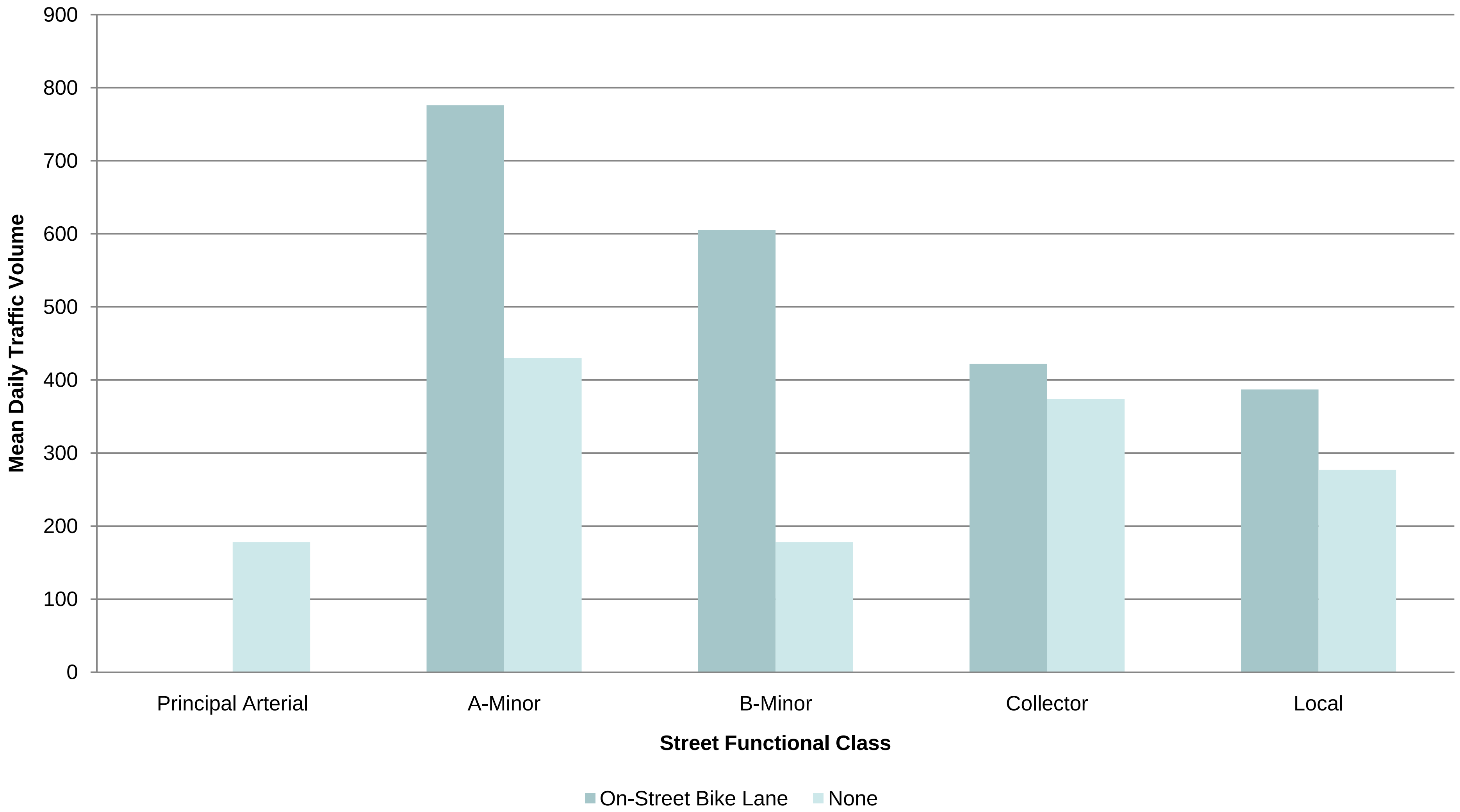
- Bike traffic model: Adj. $R^2 = 0.275$
- Pedestrian traffic model: Adj. $R^2 = 0.377$

Data and Methods: Counts and Correlates of Traffic

- *Counts*: Minneapolis DPW and Transit for Livable Communities (manual; n=458)
- *Type of bike facility*: Minneapolis DPW
- *Street/road classification*: Metropolitan Council
- *Bus lines*: Metro Transit
- *Daily weather*: National Oceanic and Atmospheric Administration (NOAA)
- *Neighborhood demographics*: U.S. Bureau of the Census
- *Neighborhood land use*: City of Minneapolis

Mean Bike Traffic Volumes by Street & Facility Type

(Minneapolis, 12-hour observations (6:30 a.m. – 6:30 p.m.; n=458)



Pedestrian Traffic Volumes by Street Type

(Minneaposlis, 12-hour observations (6:30 a.m. – 6:30 p.m.; n=453)

	Principal Arterial	A-Minor	B-Minor	Collector	Local	All Streets	Trails
Observations	**6**	**160**	**72**	**58**	**63**	**359**	**94**
Maximum volume	150	18,153	6,230	13,424	1,476	18,153	14,779
Mean 12 hour volume	**87**	**1,005**	**939**	**1,447**	**355**	**934**	**440**
Median volume	86	674	315	461	230	443	114
Minimum volume	36	0	43	4	0	0	0
Average hourly volume	7	84	78	121	30	78	37

Pedestrian Volumes, Bus Lines, & Trails

(Minneaposli, 12-hour observations (6:30 a.m. – 6:30 p.m.; n=453)

	On Bus Route	None
Observations	**266**	**97**
Maximum volume	18,153	8,492
Mean 12 hour volume	**1,123**	**531**
Median volume	554	229
Minimum volume	0	0
Average hourly volume	94	44

Regression Model Results

Weather Variables	Effect on Bicycle Traffic	Effect on Pedestrian Traffic
Maximum daily temperature	**+++**	Not significant
Deviation from average temperature	**--**	Not significant
Precipitation (any)	**-**	Not significant
Wind speed (average)	Not significant	Not significant

-, + significant at 10% level
--, ++ significant at 5% level
---,+++ significant at 1% level

Model Results, cont.

Neighborhood Variables*	Effect on Bicycle Traffic	Effect on Pedestrian Traffic
% Population > 65, < 5	++	Not significant
Median household income	Not significant	--
% Population with college degree	++	+
% Black population	-	Not significant
% Other race	Not significant	Not significant
Population density	Not significant	Not significant

*Estimated for Census block group where counting location falls
-, + significant at 10% level
--, ++ significant at 5% level
---,+++ significant at 1% level

Model Results, cont.

Neighborhood Variable*	Effect on Bicycle Traffic	Effect on Pedestrian Traffic
Violent crimes per capita	- - -	- - -
Employment accessibility	+++	+++
Land use mix	+++	+++

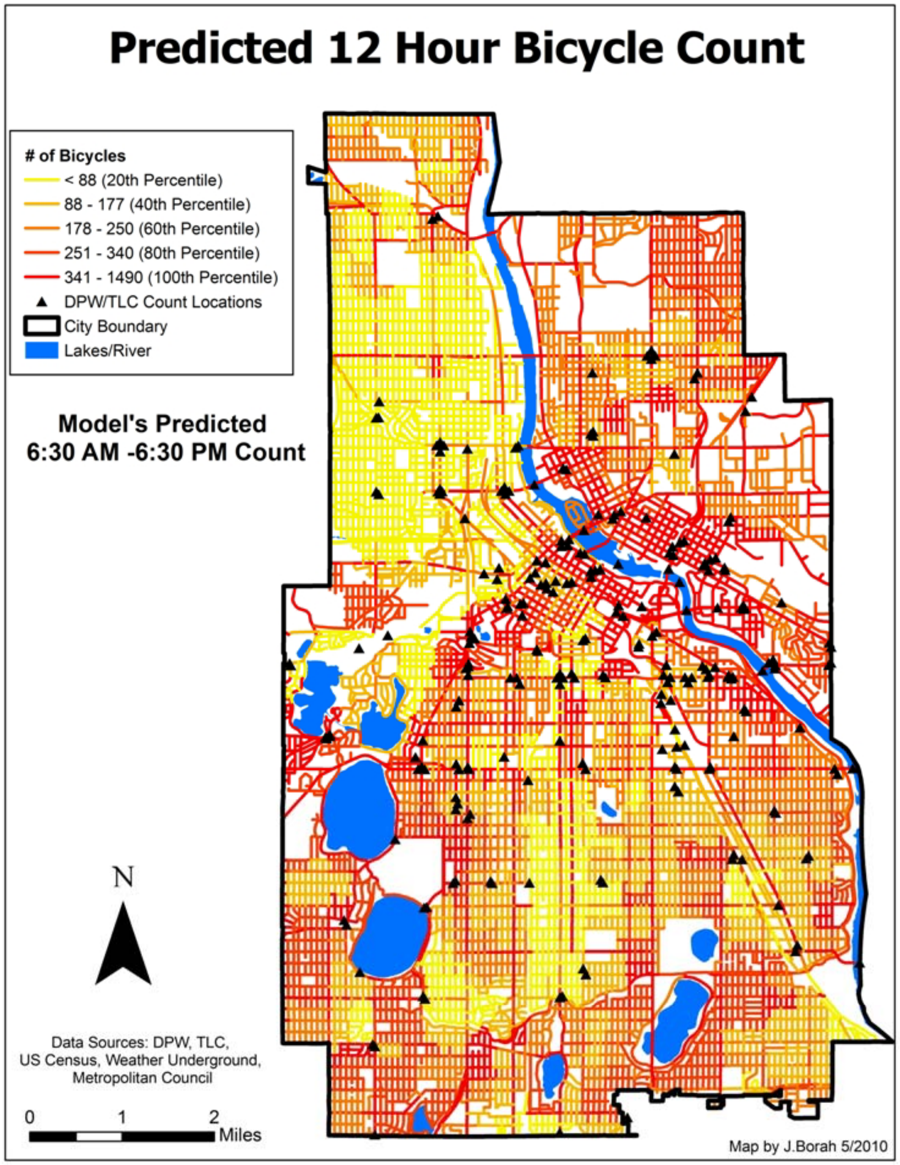
*Estimated for Census block group where counting location falls
-, + significant at 10% level
--, ++ significant at 5% level
---,+++ significant at 1% level

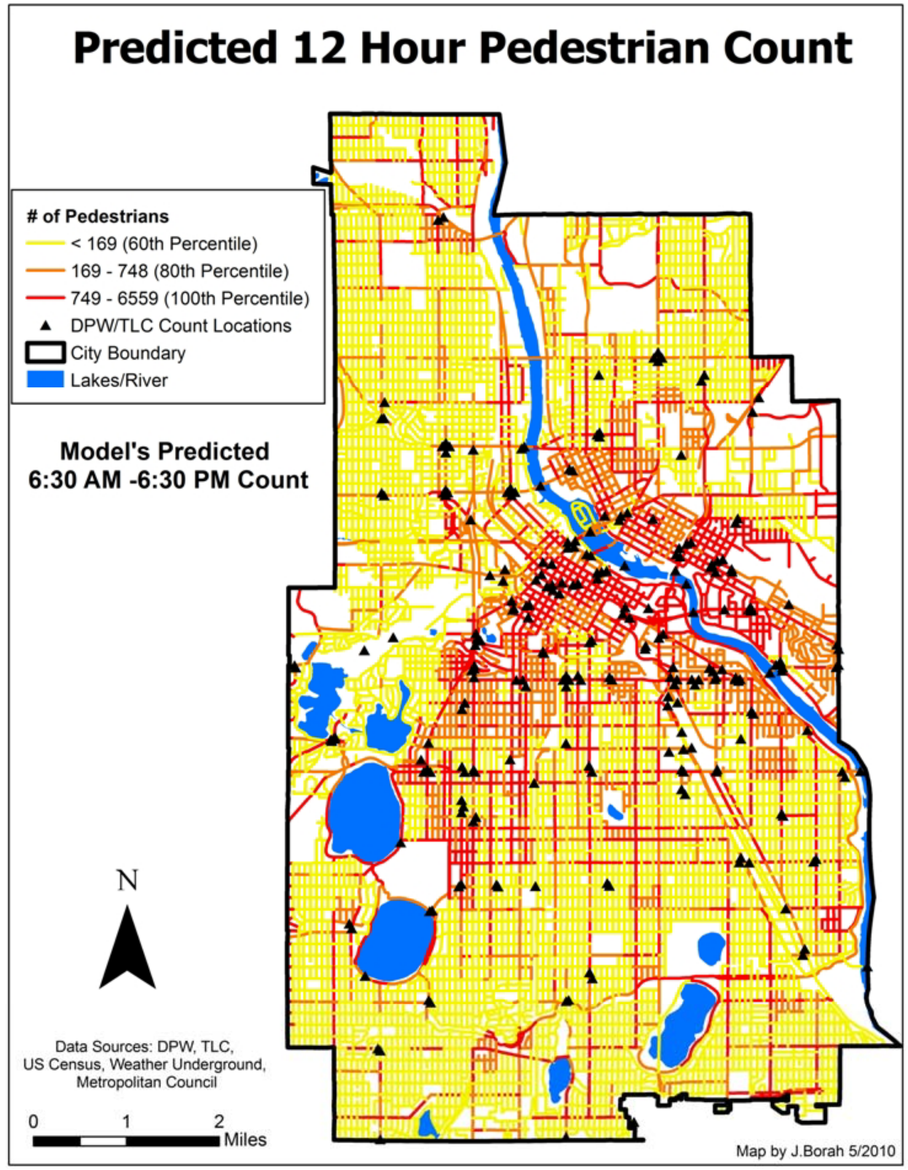
Model Results, cont.

Road Infrastructure Variable	Effect on Bicycles (relative to local street, no bike facility)
Principal arterial with bike facility	No counts
Minor arterial with bike facility	**+++**
Collector with bike facility	Not significant
Local with bike facility	Not significant
Principal arterial, no facility	Not significant
Minor arterial, no facility	Not significant
Collector, no facility	Not significant
Off-street bike facility	**+++**
Presence of bus line	Not significant
Local, no facility	(base case)
-, + significant at 10% level --, ++ significant at 5% level ---,+++ significant at 1% level	

Model Results, cont.

Road Infrastructure Variable	Effect on Peds (relative to off-street facility)
Principal arterial	Not significant
Minor arterial	Not significant
Collector	**+++**
Local	Not significant
Presence of bus line	Not significant
Off-street bike facility	(base case)
-, + significant at 10% level --, ++ significant at 5% level ---,+++ significant at 1% level	


Predicted 12 Hour Bicycle Count
# of Bicycles
< 88 (20th Percentile)
88 - 177 (40th Percentile)
178 - 250 (60th Percentile)
251 - 340 (80th Percentile)
341 - 1490 (100th Percentile)
DPW/TLC Count Locations
City Boundary
Lakes/River
Model's Predicted
6:30 AM -6:30 PM Count
N
Data Sources: DPW, TLC,
US Census, Weather Underground,
Metropolitan Council
0
1
2
Miles
Map by J.Borah 5/2010


Predicted 12 Hour Pedestrian Count
# of Pedestrians
< 169 (60th Percentile)
169 - 748 (80th Percentile)
749 - 6559 (100th Percentile)
DPW/TLC Count Locations
City Boundary
Lakes/River
Model's Predicted
6:30 AM -6:30 PM Count
N
Data Sources: DPW, TLC,
US Census, Weather Underground,
Metropolitan Council
0
1
2
Miles
Map by J.Borah 5/2010

Observations

- Bike and ped traffic varies temporally and spatially in consistent patterns
- Bike and ped traffic is highly correlated with:
  - Weather, month, day of week
  - Socioeconomic status of neighborhoods
  - Some aspects of urban form and facility characteristics
- Models have limitations
  - Theoretical models are incomplete (e.g., crime)
  - Correlation is not causation

Potential Uses of Counts and Models

- Inform counting and evaluation strategies (e.g., increase efficiency of field sampling)
- Generalize ad hoc counts using seasonal, day-of-week, and time-of-day ratios (i.e., scaling factors)
- Inform planning and investment decisions about future bicycle and pedestrian infrastructure
- Inform safety management (e.g., stoplight warrants)
- Improve urban design
- Facilitate interdisciplinary research (e.g., health impacts of cycling or walking on busy streets)
- Support initiatives to enhance quality of life

Observations

- All counts and models are “wrong”
- Modest efforts can produce useful estimates
- Estimates helpful for many policy, managerial, and operational decisions
- Research can inform policy and management

A Call to Count!

- National Bicycle and Pedestrian Documentation Project
- Faculty researchers and instructors
  - Great opportunity for civic engagement
  - Engage students in counting
  - Modular approaches to collection of data

National Bicycle & Pedestrian Documentation Project

- Bike-Pedestrian Counting Equipment 101
- Adjustment Factors
- NBPD Counts Training
- NBPD Survey Training
- NBPD Facts and FAQs

Alta Design (http://bikepeddocumentation.org/)