

Modeling Urban Greenway Trail Use: The Importance of Trail Characteristics



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Support:

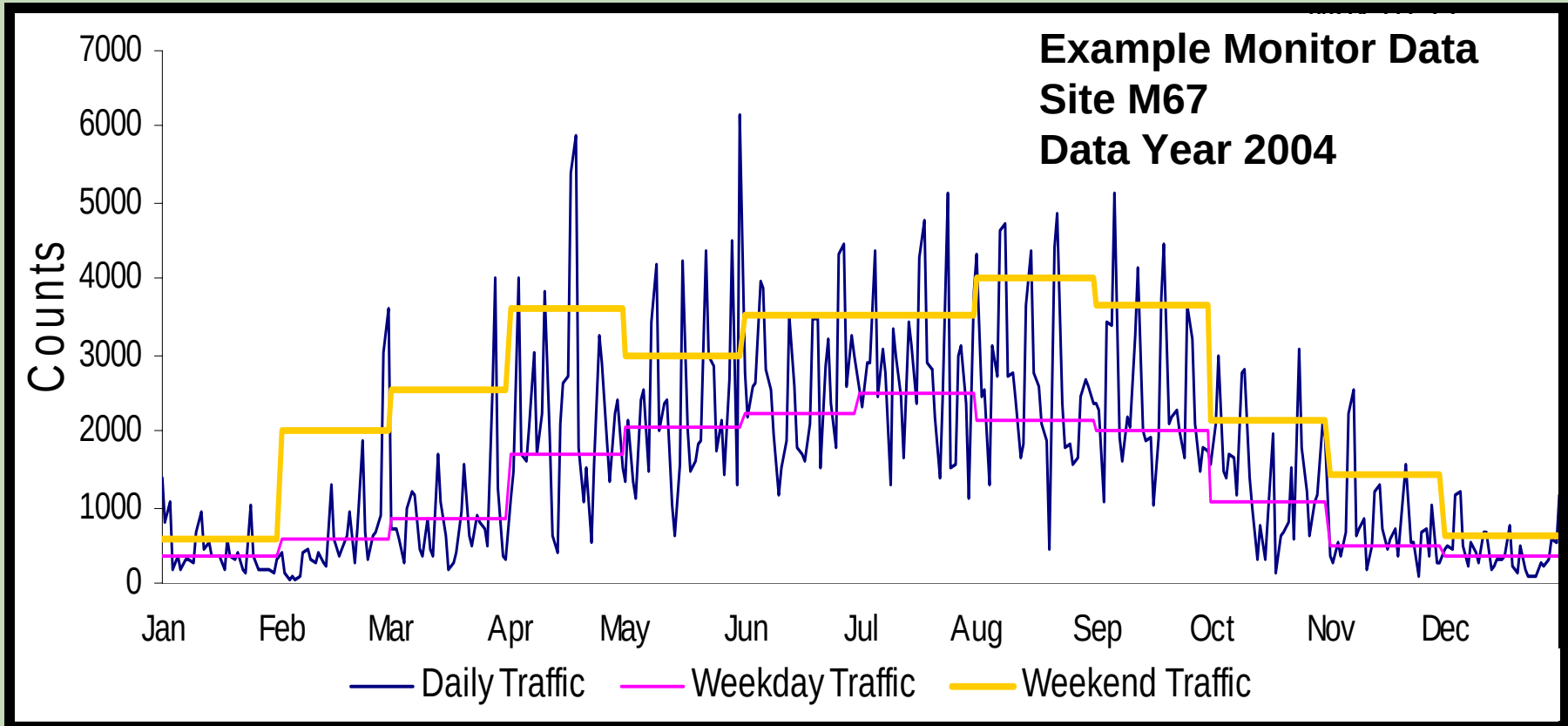
***Active Living Research Program
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Objectives

- Primary Aims:
 - to establish objective measures of:
 - urban trail traffic
 - characteristics of trails and surrounding neighborhoods (physical and socio-demographic)
 - to identify correlates of trail traffic / develop forecasting model
 - to inform health, planning, design, recreation, and transportation literatures
- Extend existing model of daily trail traffic (Lindsey et al. *JPAH* 2006)
 - 18,000 observations of daily traffic on 30 trail segments in Indianapolis, IN
 - 29 explanatory variables; Adj. $R^2 = 80\%$
 - time, weather, neighborhood socio-demographics and urban form
 - characteristics of trails not included
- New Measures, Models, and Results
 - additional 6,000 monitoring days: July 2005 – Dec. 2005
 - **derived new objective measures of trails**
 - trail amenities
 - trail characteristics and form
 - **viewsheds analyzed using LIDAR data**

Trail Monitoring

- Five trails, 33 mile network, 30 monitoring sites
 - 4 locations 06/2001 – 12/2005
 - 2 locations 06/2002 – 12/2005
 - 24 locations 05/2004 – 12/2005
- Monitoring 24 / 7 / 365
- Total daily traffic counts ($n = 24,177$)

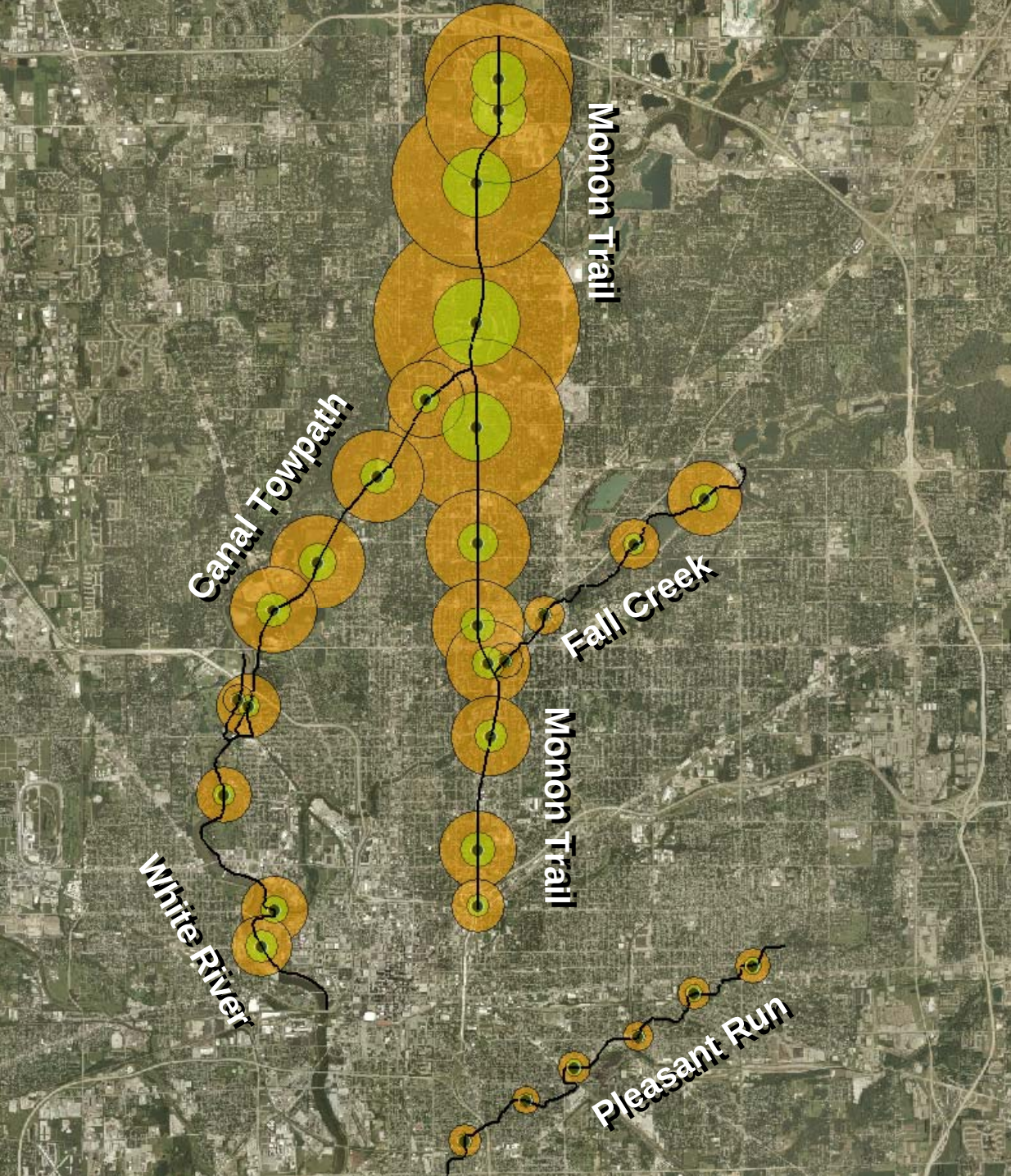
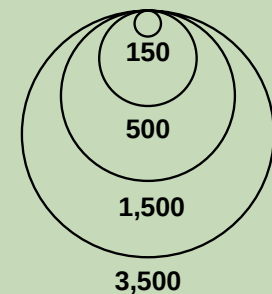


Spatial and Temporal Variation in Trail Use

Example of spatial and temporal variability in trail use depicting mean counts for week days and weekend days in September 2004.

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

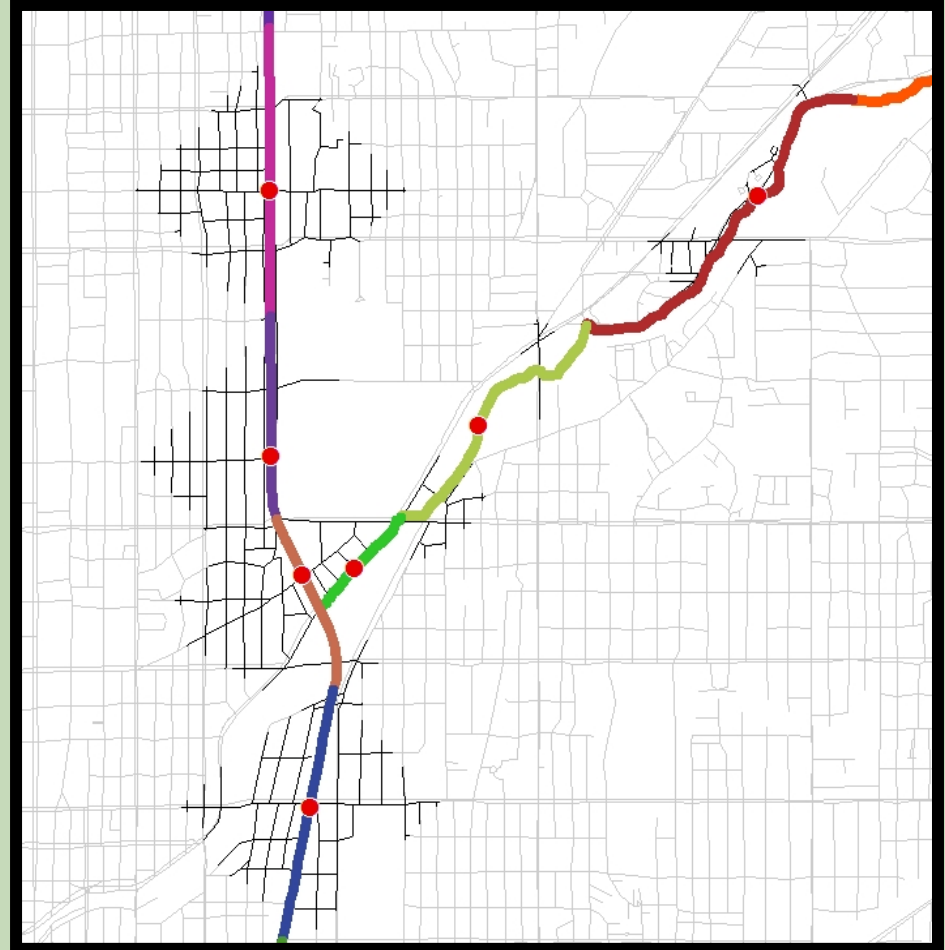
Mean Daily Count



Nighborhood Delineation



Segment Delineation



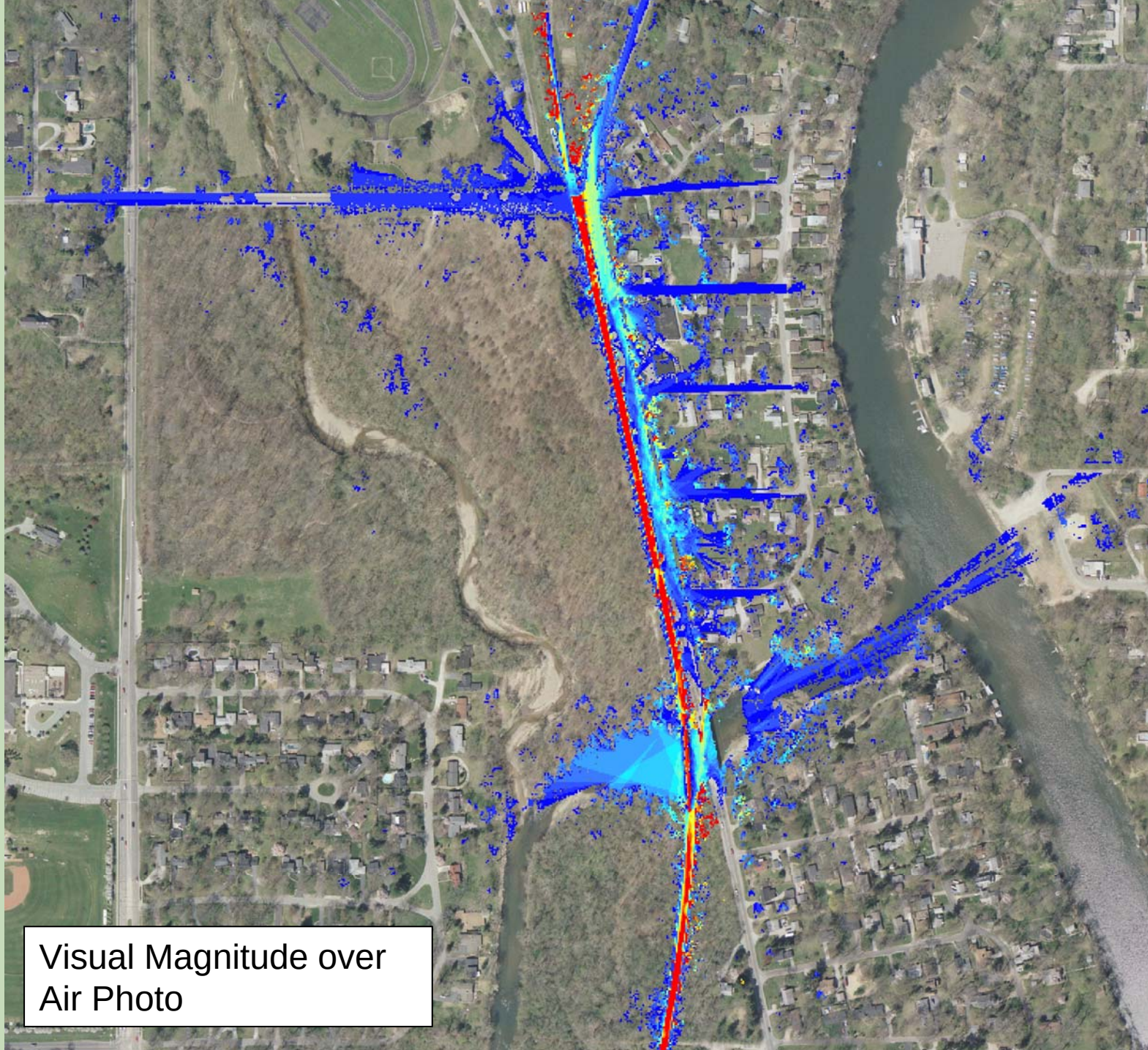
 ½ Mile Route  Monitor
 Roads  Trail

 Trail Segments
 ½ Mile Routes
 Monitor

Light Detection And Ranging (LIDAR)

- optical equivalent of RADAR or SONAR
- active laser sensors transmit pulse of light energy
- energy is reflected back to the instrument
- timing of laser pulse converted to X,Y,Z measurements
- accurate to within a few centimeters
- Indianapolis LIDAR data acquired Spring 2003
- >3 billion XYZ points, 145GB for entire city
- developed 5ft resolution surface feature elevation models for ½ mile buffer around each segment
- viewshed algorithm implemented at 4173 points every 40ft along each segment assuming six foot observer height
- viewsheds unrestricted for angle and azimuth, but limited to ½ mile from trail





Visual Magnitude over
Air Photo

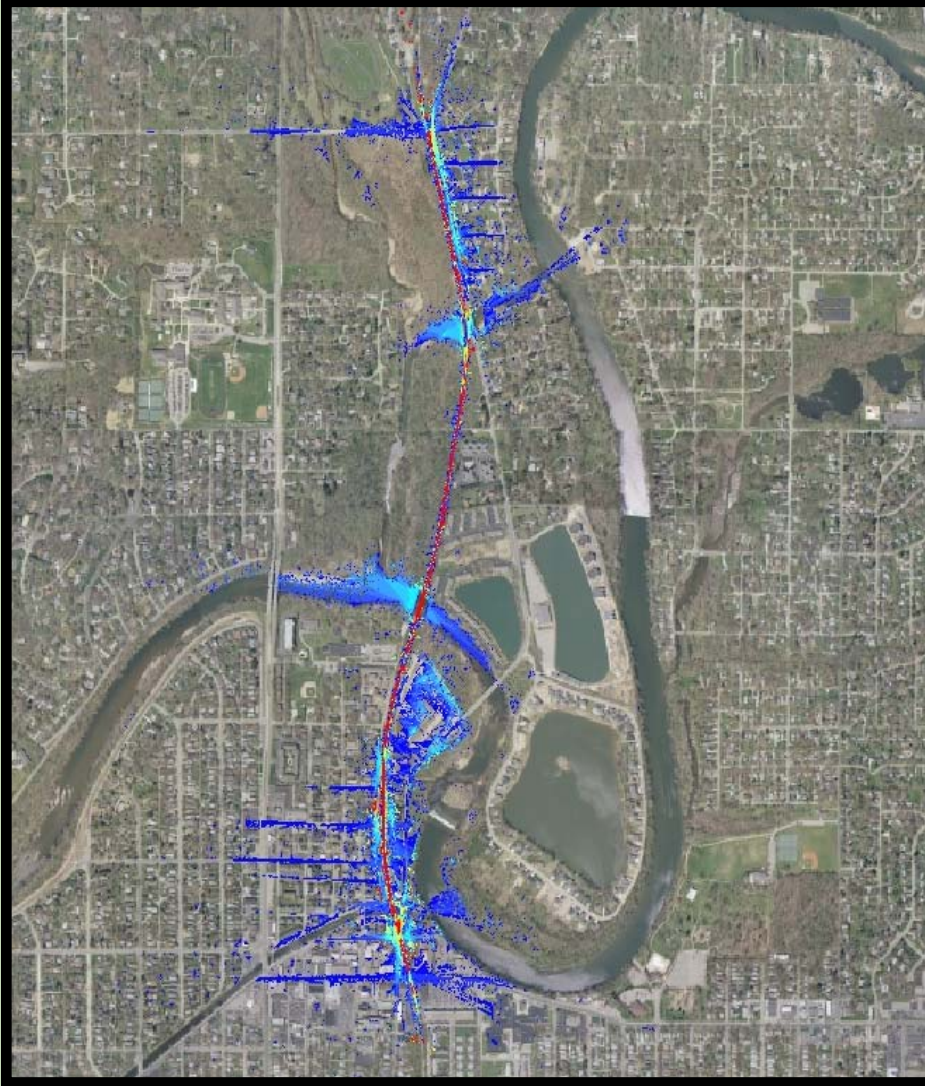


Segment CTM PctVis = 1.5%

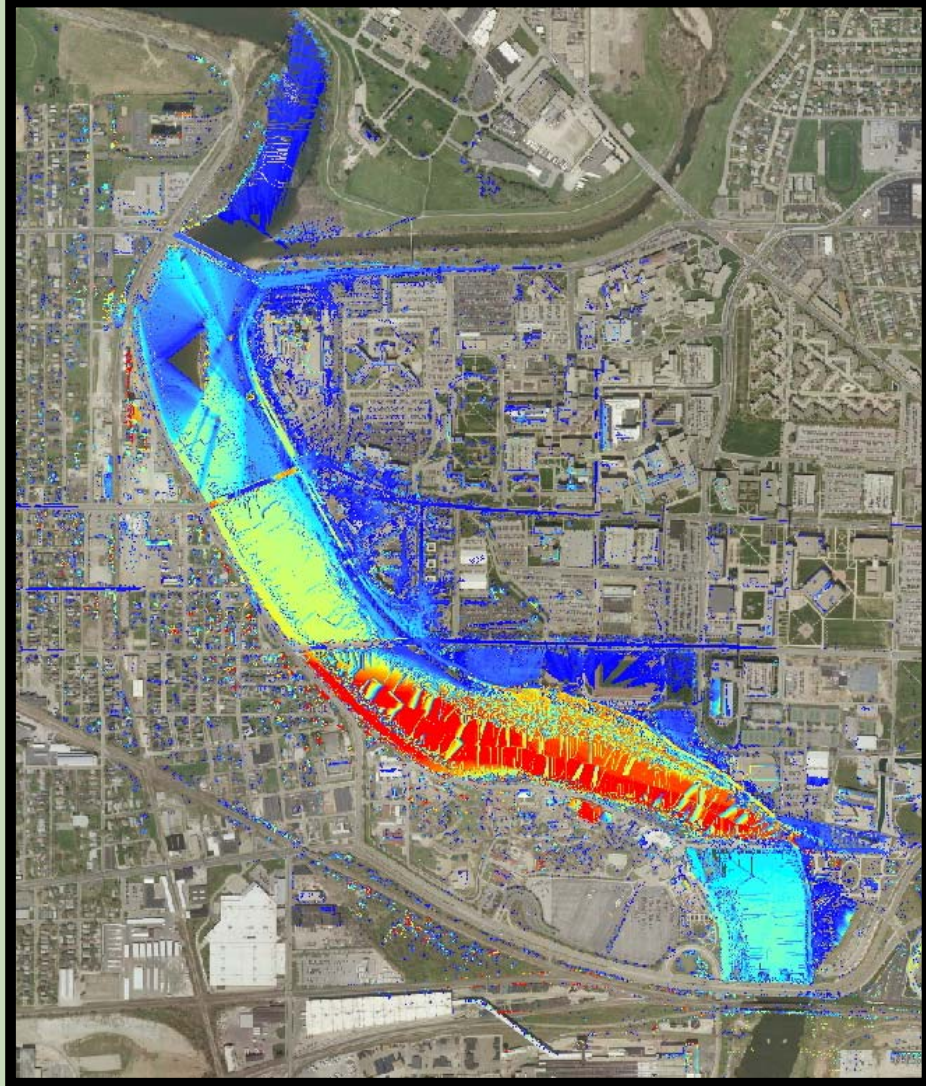


Segment PLR5 PctVis = 8.5%

Percent Area Visible from Trail
(within ½ mile buffer)



Segment M67 AvgVisMag = 4.9



Segment WM AvgVisMag = 26.1

Low  High

Visual Magnitude

Index of interconnectedness of viewsheds



Segment WR SHDI = 0.65

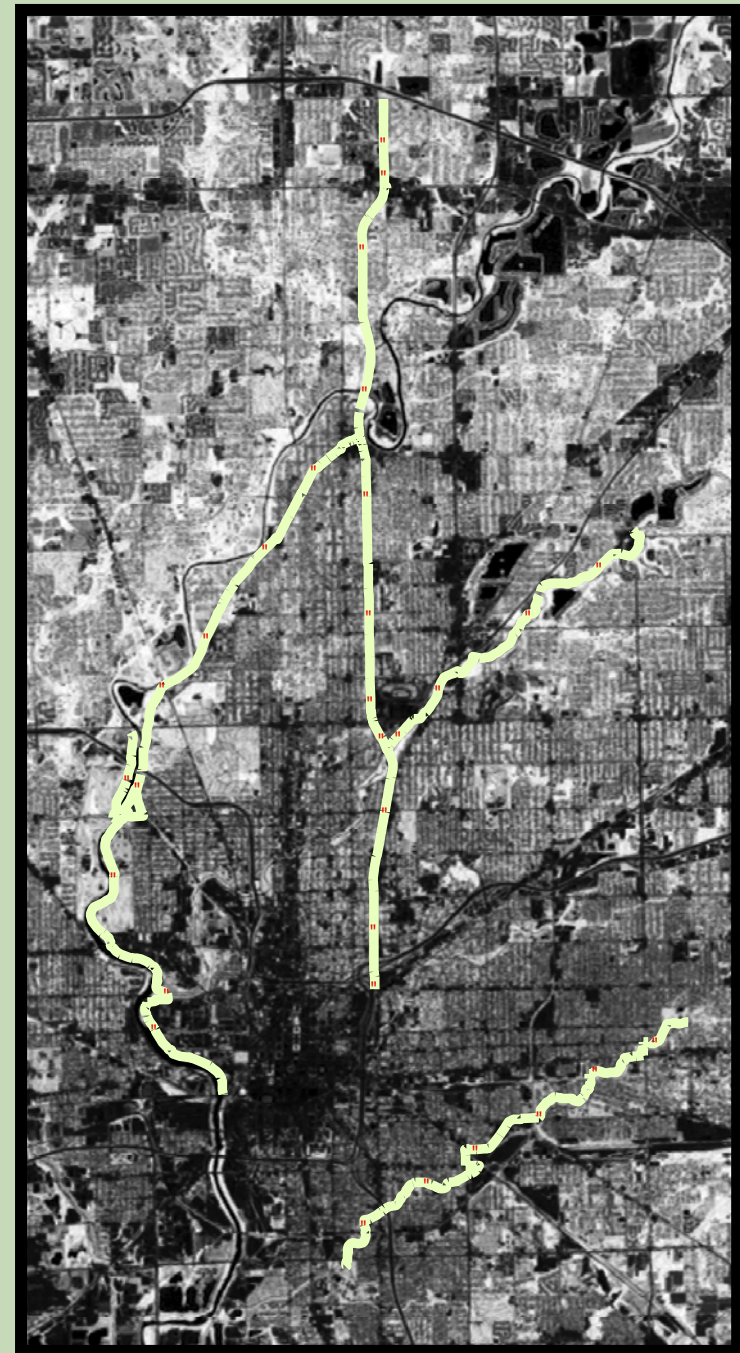


Segment M49 SHDI = 1.36

Shannon's Diversity Index (SHDI)
(calculated on land use in each segment viewshed)

Normalized Difference Vegetation Index (NDVI)

- remote sensing algorithm for measuring vegetation
- based on differences in red and NIR reflectance
- $NDVI = (NIR - red) / (NIR + red)$
- unitless index with possible range of -1 to +1
- higher values - dense green healthy vegetation
- lower values - stressed vegetation, bare ground, water
- extensive research shows significant correlations between NDVI and a variety of biophysical vegetation characteristics:
 - green biomass, leaf area index, % vegetation ground cover
- Landsat ETM+ mean NDVI values computed within trail neighborhoods and viewsheds
- difference between trail and neighborhood NDVI used in final model (((USE EQUATION?))



Model Variables

Temporal	Description	Hypothetical Effect
Weekend	Dummy variable, 1 if weekend day, 0 otherwise	positive
Jan – Nov	Dummy variable, 1 if January, 0 otherwise (December omitted)	positive
StateFair	Dummy variable, 1 if State Fair in session, 0 otherwise	positive

Weather		
TempDev	Deviation of daily temperature from long-term average, in Fahrenheit	positive
PrecipDev	Deviation of daily precipitation accumulation from long-term average, in inches	negative
SnowDev	Deviation of daily snow accumulation from long-term average, in inches	negative
SunDev	Deviation of daily percentage sunshine from long-term average	positive

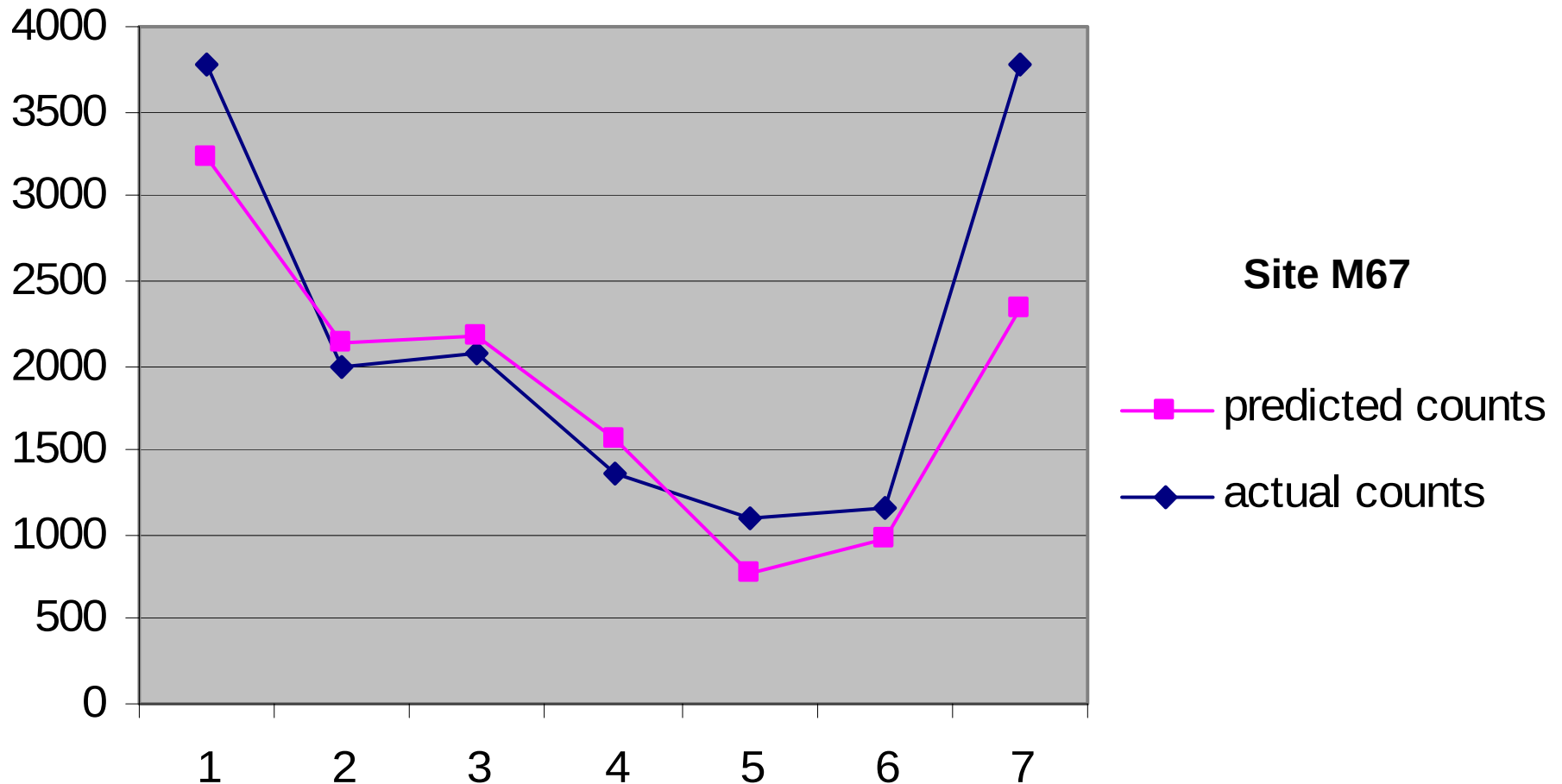
Model Variables

Neighborhood Socio-Demographics	Description	Hypothetical Effect
YoungOld%	Percentage Population less than 5 and greater than 64	negative
Black%	Percentage African American	negative
Other%	Percentage other ethnicity, exclude White and African American	negative
College25Ave%	Mean Percentage Population 25+ with College Degree	positive
MHHIncAve	Mean of Median Household Incomes, in dollars	positive

Neighborhood Urban Form		
PopDensity	Population density in 1/2 mile network distance to monitor	positive
Commercial%	Percentage of commercial land use in trail neighborhood	positive
PrkLotArea	Parking lots (Square Feet) in trail neighborhood	positive
StreetLngh	Average length of network street segments within 1/2 mile of counter	positive

Validation of *JPAH* Model

Example of daily trail traffic forecasting for week of September 11 – 17, 2005
using data collected between June 2001 – July 2005



New Trail Segment Characteristics

Viewsheds

Trail Segment Characteristics	Description	Hypothetical Effect
Openness	Percent total area visible within ½ mile of trail segment	positive
Interconnectedness	Average value of visual magnitude for segment	?
Land Use Diversity	Shannon's Diversity Index of land use in segment viewshed	positive
Greenness	Difference between mean NDVI of neighborhood and trail viewshed (trail viewshed – neighborhood = D_NDVI)	positive
Percent Not Paved	Percent trail length with non-paved surface (e.g., gravel)	negative
Railroad Xing	Number of railroad crossings at grade, Dummy variable, 1 = present, ($n = 2$)	negative
Trail Intersection	Dummy variable, 1 = trail segment connects to a segment on a different trail (otherwise 0)	positive
Amenity Density	Number art, bench, wayfinding signs divided by segment length	positive
Average Slope	Average slope along trail segments	?
Sinuosity	Sinuosity of trail segment	? (positive for nature trails)
Road Xing Density	Segment length / number of road crossings at grade	negative (interrupts use) positive (access)

New Interim Modeling Results

- Trail Traffic Models (dependent variable = ln daily traffic count)
 - 38-40 correlates: 10-12 measures of trail characteristics
- Corroborate previous findings
 - temporal variables: significant, expected direction
 - weather variables: significant, expected direction
 - neighborhood socio-demographic variables: significant, expected direction, except
 - neighborhood race measures change sign with introduction of indices of trail amenities
 - urban form variables: significant, expected direction except
 - street segment length inconsistent with theory (old and new model)
 - population density not significant in all new models
- Trail characteristics
 - viewshed variables significant, expected direction
 - not all correlates stable (signs, significance vary)

Trail Characteristics (indices of trail amenities change signs and significance of other neighborhood and trail variables)	Model 1 (Adj. R ² = 0.82)		Model 2 (Adj. R ² = 0.85)	
	Sign	Sig.	Sign	Sig.
Openness	+	Yes	+	Yes
Interconnectedness	-	Yes	-	Yes
Land Use Diversity	+	Yes	+	Yes
Greenness D_NDVI_060600	+	Yes	+	Yes
Percent not paved	-	Yes	-	Yes
RR Xing (dummy)	-	Yes	-	Yes
Trail intersection (dummy)	-	Yes	-	Yes
Art (density)			+	Yes
Benches (density)			+	Yes
Average slope	-	Yes	+	Yes
Sinuosity	+	No	-	Yes
Road Xing (density)	+	Yes	-	Yes

Conclusions

- Daily trail traffic can be modeled
- Correlates of daily trail traffic include time, weather, neighborhood socio-demographics, neighborhood urban form, and trail characteristics
- Trail use is
 - positively correlated with open trail viewshed, viewshed interconnectedness, land use diversity, and greenness or vegetative health
 - negatively correlated with percent of trail not paved and presence of railroad crossings
- Interactions with trail amenity variables (density of art, benches) change signs on slope, sinuosity, and road crossing variables and neighborhood variables such as race and population density
- Additional research required to sort out effects of these trail measures
- From forecasting perspective, marginal gains in explanatory power may not justify viewshed analyses (computationally intensive)
- Theoretical model of trail traffic incomplete
- Ongoing research will produce objective and subjective measures to augment analyses (e.g., measures of neighborhood and trail-related crime)

