Measures of Urban Trail Use in Minneapolis
Why Measure Trail Use?

- 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
- Further research and inform theory
Some Terms

- **Traffic count**: 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
Methods of Counting

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

• Bold = methods used in Minneapolis
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

<table>
<thead>
<tr>
<th>Method of observation</th>
<th>Manual</th>
<th>Magnetic Loop Detector</th>
<th>Active Infrared Counters (beam/sensors)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traffic observed</strong></td>
<td>Cyclists (bi-directional)</td>
<td>Cyclists only (bi-directional, potentially)</td>
<td>Cyclists &amp; Peds combined (no directional)</td>
</tr>
<tr>
<td></td>
<td>Ped (bi-directional)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>Choice of time units</td>
<td>15 minute blocks</td>
<td>Time of event</td>
</tr>
<tr>
<td><strong>Locations for deployment</strong></td>
<td>On and off-street facilities &amp; no facilities</td>
<td>Off-street facilities</td>
<td>Depends on counter type and facility characteristics</td>
</tr>
<tr>
<td><strong>Length of observations</strong></td>
<td>Based on staff availability (often two-hour blocks)</td>
<td>Continuous: 24 hours</td>
<td>Continuous: 24 hours</td>
</tr>
<tr>
<td><strong>Limitations</strong></td>
<td>Human error</td>
<td>Must calibrate</td>
<td>Must calibrate; systematic undercount (beam counters)</td>
</tr>
</tbody>
</table>
## Minneapolis Example: Methods of Counting, con’t.

<table>
<thead>
<tr>
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<th>Manual</th>
<th>Magnetic Loop Detector</th>
<th>Active Infrared Counters (beam/sensors)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources of error</strong></td>
<td>Distractions</td>
<td>Misses riders on edge of trail.</td>
<td>Misses users passing simultaneously</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Direction of riders in wrong lanes recorded incorrectly</td>
<td></td>
</tr>
<tr>
<td><strong>Data recorded</strong></td>
<td>5 – 60 minute time intervals</td>
<td>15 minute counts</td>
<td>Time of “event”; can be aggregated to any time period</td>
</tr>
<tr>
<td><strong>Other considerations</strong></td>
<td>Can record groups, some user characteristics</td>
<td>Can’t measure user characteristics</td>
<td>Can’t measure user characteristics</td>
</tr>
</tbody>
</table>
Trail Counter Locations in Minneapolis
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
Assess Reliability of Manual Counts

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

<table>
<thead>
<tr>
<th>Comparison Hour</th>
<th>Date</th>
<th>Start Time</th>
<th>End Time</th>
<th>Counter #1</th>
<th>Counter #2</th>
<th>Abs Val Error</th>
<th>Abs Val % Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29 July 2010</td>
<td>9:00</td>
<td>10:00</td>
<td>188</td>
<td>183</td>
<td>5</td>
<td>2.7%</td>
</tr>
<tr>
<td>2</td>
<td>29 July 2010</td>
<td>10:00</td>
<td>11:00</td>
<td>183</td>
<td>180</td>
<td>3</td>
<td>1.6%</td>
</tr>
<tr>
<td>3</td>
<td>29 July 2010</td>
<td>11:00</td>
<td>12:00</td>
<td>184</td>
<td>183</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td>4</td>
<td>29 July 2010</td>
<td>12:00</td>
<td>13:00</td>
<td>197</td>
<td>205</td>
<td>8</td>
<td>4.1%</td>
</tr>
<tr>
<td>5</td>
<td>29 July 2010</td>
<td>13:00</td>
<td>14:00</td>
<td>218</td>
<td>219</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td>6</td>
<td>29 July 2010</td>
<td>14:00</td>
<td>15:00</td>
<td>230</td>
<td>233</td>
<td>3</td>
<td>1.3%</td>
</tr>
<tr>
<td>7</td>
<td>05 August 2010</td>
<td>11:00</td>
<td>12:00</td>
<td>184</td>
<td>184</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>8</td>
<td>05 August 2010</td>
<td>12:00</td>
<td>13:00</td>
<td>202</td>
<td>201</td>
<td>1</td>
<td>0.5%</td>
</tr>
</tbody>
</table>
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
Active Infrared Trail Monitors
(Trailmaster ®, bikes & peds)

Raw Data

- 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 Trail Monitors

**Trailmaster ®, bikes & peds**

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

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**Active Infrared Count Calibration (Bicycles + Pedestrians)**

\[
y = 0.0002x^2 + 1.0655x - 1.2937  \\
R^2 = 0.9958
\]

\[
y = 1.1661x - 9.5489  \\
R^2 = 0.9951
\]

Graph showing the comparison between manual hourly counts and TrailMaster hourly counts. The graph includes data for Hennepin Ave, W River Pkwy, and Cedar Ave, each with a different number of observations (n=84, n=41, n=5). There is also a 1:1 hypothetical line for comparison.
Working with Trail 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
Mean Daily Bike Traffic Volumes
(Magnetic Loop Detector, Midtown Greenway (uncorrected))

![Graph showing mean daily bike traffic volumes from January 2007 to January 2010 for Hennepin Ave, Cedar Ave, and West River Pkwy.]
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, Daily, and, Spatial Variation in Trail Traffic

Weekdays

Midtown Greenway Sites

ADT = 1000

Weekend-Weekday Ratios

Ratio = 1

MPRB Trail Sites

ADT = 1000

Ratio = 1
Weekday and Weekend Time of Day Variation in Trail Traffic

Midtown-Hennepin

Lake Calhoun Trail

Weekdays

Weekends
Table 4. An Exploratory Statistical Model of Minneapolis Trail Traffic

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fixed Effects Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjusted-R²</strong></td>
<td>0.7376</td>
</tr>
<tr>
<td><strong>Weather Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>Temperature max</td>
<td>Beta: 40.40, t-statistic: 42.31, Significance: 0.000</td>
</tr>
<tr>
<td>Max temp deviation</td>
<td>Beta: -16.50, t-statistic: -7.41, Significance: 0.000</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Beta: -464.9, t-statistic: -5.94, Significance: 0.000</td>
</tr>
<tr>
<td>Wind average</td>
<td>Beta: -30.50, t-statistic: -6.29, Significance: 0.000</td>
</tr>
<tr>
<td><strong>Temporal Dummies</strong></td>
<td></td>
</tr>
<tr>
<td>weekend</td>
<td>Beta: 289.1, t-statistic: 7.23, Significance: 0.000</td>
</tr>
<tr>
<td><strong>Location Dummies</strong></td>
<td></td>
</tr>
<tr>
<td>Hennepin</td>
<td>Beta: 732.5, t-statistic: 11.27, Significance: 0.000</td>
</tr>
<tr>
<td>West River Prkway</td>
<td>Beta: -159.5, t-statistic: -2.43, Significance: 0.015</td>
</tr>
<tr>
<td>Cedar</td>
<td>Beta: 563.2, t-statistic: 7.84, Significance: 0.000</td>
</tr>
<tr>
<td>Calhoun</td>
<td>Beta: 917.5, t-statistic: 12.56, Significance: 0.000</td>
</tr>
<tr>
<td>Nokomis</td>
<td>Beta: 417.6, t-statistic: 5.67, Significance: 0.000</td>
</tr>
</tbody>
</table>
Observations about Trail Traffic

• Multiple methods available for counting
• All counts are “wrong” – all measurement methods require calibration
• Traffic varies temporally & spatially, but consistently
• Traffic correlated with weather, day of week, location
• Statistical models explain approximately three-quarters of variation in traffic
• Models not fully specified; limited to monitoring sites
• 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
# Inform Traffic Safety: Street-Trail Crossings

<table>
<thead>
<tr>
<th>Street (mid-block crossing)</th>
<th>Street Average Daily Traffic</th>
<th>Trail Estimated Daily Traffic</th>
<th>Recommendations (selected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local 1</td>
<td>420</td>
<td>3,280</td>
<td>Add street stop sign; remove trail stop sign</td>
</tr>
<tr>
<td>Local 2</td>
<td>2,026</td>
<td>3,280</td>
<td>Add street stop sign; remove trail stop sign</td>
</tr>
<tr>
<td>Local 3</td>
<td>2,400</td>
<td>3,280</td>
<td>Add street stop sign; remove trail stop sign</td>
</tr>
<tr>
<td>Local 4</td>
<td>1,680</td>
<td>2,900</td>
<td>Add street yield sign; remove trail stop sign</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>7,267</td>
<td>2,740</td>
<td>Trail stop sign, add overhead flasher; reduce vehicles lanes from 4 to 2 at crossing</td>
</tr>
</tbody>
</table>

Minneapolis Dept. of Public Works, Feb. 15, 2010
Next Steps

• Continue counting at existing locations
• Increase number of counting locations
• Explore insights from co-location of different counters (i.e., loop-detector and infrared)
• Refine statistical models
• New Mn/DOT project: