T-MAP: From Niche to Norm

A Practitioner-Rooted Research Project

Keith Laughlin
President, Rails-to-Trails Conservancy
Active Living Research Conference
March 8, 2014
My Role on the Panel

To create advocacy context for the research to follow
RTC 101

- Founded in 1986
- 150,000 Members and supporters
- HQ in DC with 4 Regional Offices
- 40+ Staff
Our Mission

“To create a nationwide network of trails from former rail lines and connecting corridors…

…to build healthier places for healthier people.”

- Adopted Oct 2004
“Health” in Multiple Dimensions

Improving the…

• …economic and environmental health of a place
• …personal health of its people
• …social health of a community
Our Methods:
Catalyzing Change in 3 Spheres

#1
Changing Public Policy

#2
Changing Public Infrastructure

#3
Changing Personal Behavior
Our Methods:
Catalyzing Change in 3 Spheres

#1
Changing Public Policy

#2
Changing Public Infrastructure

#3
Changing Personal Behavior

T-MAP
Shameless Plug: Sphere #1: Changing Policy

Safe Routes to Everywhere
Building Healthy Places for Healthy People Through Active Transportation Networks
Looking Back

Past success:
• 1986: 250 miles
• 2014: >21,000 miles
Our Big, Hairy, Audacious Goal: By 2020, 90 percent of Americans will live within three miles of a local trail system.
Measuring the BHAG: Creating Geospatial Data Base

• Since 2006 we have mapped 25,500 miles of multi-purpose trail in the US
• Overlay with Census data to measure proximity
National Progress on BHAG

- Dec. 2009: 25.5%
  - 14,700 miles of trail
- Dec. 2010: 32.5%
  - 17,500 miles of trail
- Dec. 2011: 39.8%
  - 21,700 miles of trail
- Dec. 2012: 42.2%
  - 23,500 miles of trail
- Dec. 2013: 44.0%
  - 25,200 miles of trail
State-Level Analysis: 2013

1. District of Columbia (100%)
2. Rhode Island (75%)
3. Colorado (70%)
4. Washington (68%)
5. Illinois (66%)
6. California (62%)
7. New York (58%)
8. Nebraska (58%)
9. Oregon (58%)
10. Wisconsin (56%)
MSA-Level Analysis
MSA-Level Analysis

1. Rockford, IL (93%)
2. San Francisco-Oakland-Fremont, CA (92%)
3. San Jose-Sunnyvale-Santa Clara, CA (92%)
4. Boulder, CO (91%)
5. Lincoln, NE (90%)
6. Racine, WI (90%)
7. Milwaukee-Waukesha-West Allis, WI (90%)
8. Denver-Aurora-Broomfield, CO (88%)
9. Des Moines-West Des Moines, IA (85%)
10. Fort Collins-Loveland, CO (85%)
RTC’s Early Warning System

• On January 28, 2014, the Soo Line filed a notice to abandon 10.6 miles of active line between Sturtevant and Kansasville, WI.
• We notified all potentially interested parties in Wisconsin
• Wisconsin state DNR intends to rail bank this segment
• The map now looks like this…
Inescapable Conclusion

- Measuring proximity is useful, but limited
- It does not address equity
- It does not ensure usage
- **Accessibility and connectivity** are crucial factors in determining if infrastructure change supports behavior change
- **Key Question:** Does infrastructure effectively connect people and places?
The Genesis of T-MAP

• Was NOT created to develop “evidence”
• Emerged last summer from a dialogue with Tracy about creating “TrailScore” to measure trail system connectivity
• I want practical tools to change the world
• Tracy, Greg & Michael want to do rigorous cutting edge peer reviewed research that will change the world
Conclusion: The Opportunity

• $7 billion in federal investment since 1991 has built 25,000 miles of multi-purpose trails across the American landscape

• Approaching a tipping point: relatively small investments to make connections to create networks will cause usage to soar

• T-MAP will ensure and demonstrate that future investment delivers a high ROI
Questions?
T-MAP
Research Design

Tracy Hadden Loh, Ph.D.
Active Living Research
3/9/14
T-MAP by Component

1. Geographic Data
2. Trail System Connectivity
   - Trail Use
   - Economic Impacts
3. Communication Advocacy Making the Case
Timeline

Year 1: Continuous Counts

Year 2: Intercept Surveys

Year 3: Beta Testing & Website Buildout
Year One Data Collection: Counts
Trail Use Research Questions

• How many visits does my trail get per year?
• What is the peak trail use on my facility?
• What is the modal distribution of my users?
Year One Deliverables: Factors

- Separate for bicyclists and pedestrians
- For all weather zones of the US
- Large sample
Year One Deliverables: Calculator

X

= TrailLink
by Rails-to-Trails Conservancy
Year One Deliverables: RTCounts!
Year One Data Collection: Trail GIS

- Time of year (season)
- Weather
- How many people live nearby
- Nearby destinations
- Trail width
- Trail surface
- Trail cleanliness
- Etc
Trail GIS Research Questions

• Which trail segment should we build next?

• What are our goals for the trail system – who and what do we want to connect?

• How can we compare potential segments as apples?

• How good a job does the trail network do of connecting origins and destinations?
Year One Deliverables:
Trail System Connectivity

• Unit of analysis is the community level
• Same method, multiple possible applications
  – Developing the method is pure research work
  – Incorporating the tool into practice is a bigger task
A very connected trail network!
The existing network is less connected, naturally.
How well does the trail network connect these origins and destinations?

Measure with a statistic that is a function of network distances between all possible point pairs – an add a penalty for non-network distance needed to connect points.

GIS allows us to calculate thousands of distances for hundreds of pairs.
How well does the trail network connect particular origins and destinations?

Clusters of households with low rates of car ownership?

Scenic destinations?

Schools?
How well does the trail network connect particular origins and destinations?

Clusters of households with low rates of car ownership?

Schools?

Scenic destinations?
Year One Deliverables: Forecasting

1. Geographic Data
2. Trail System Connectivity
   - Trail Use

Counts
Year One Deliverables: Forecasting

\[ Y = a + b_1 X_1 + b_2 X_2 + \ldots + b_p X_p \]

Model coefficients

Proposed trail variables:
Trail width, population within some distance, trail system connectivity
Year Two Data Collection: Survey

Trail User Attributes
Trail User Research Questions

• Why do people use trails?

• What percentage of trail use replaces trips that would have taken place by other modes?

• How long is the average trail trip?

• Are the different “functional classifications” of trails that we need to know about to answer these questions?
Year Two Deliverables: EIA

- Trail User Attributes
- Trail Use
- Economic Impacts
Our Co-Investigators

Dr. Greg Lindsey        Dr. Thomas Gotschi        Dr. Mike Lowry
TMAP
Monitoring and Modeling Urban Trail Traffic
9 March 2014
Our Workshop Today

- Thinking about trail traffic … an exercise
- *FHWA Traffic Monitoring Guide* (framework)
  - Some decisions to make
- Trail Traffic in Minnesota
  - Some monitoring results
  - Some factoring results
  - Some modeling results
- TMAP – trail monitoring and modeling
Motivation

• How many people are on our trails?
  » Ray Irvin, Indy Parks Greenways, 1996

• No examples of continuous monitoring of bicyclists and pedestrians
  » Hunter and Huang, 1995

• Quality of data about “number of bicyclists and pedestrian by facility … is “poor” and the “priority for better data is “high”
  » Bureau of Transportation Statistics, 2000
Key Questions

• Advocacy question
  – How do we equip trail advocates and allies with evidence and tools?

• Policy and management question
  – How do we optimize investment in infrastructure for non-motorized transportation – biking and walking?

• Research question
  – How do we monitor, measure, and model urban trail traffic?
First edition of the TMG with information on monitoring non-motorized traffic (Ch 4)
“Basic guidance … to improve the state-of-the-practice”
“Systematic monitoring…still an emerging area”
“Limited information … about best and most cost-effective way to automatically collect non-motorized traffic data”
# FHWA Traffic Monitoring Guide

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

- Scale of non-motorized data collection more limited
- More experience with manual (very) short-duration counts (e.g., 2 hours) than automated counts
- Technologies for automated non-motorized counting still evolving; error rates unknown
- Standard procedures for analyzing data not developed
What are implications of differences in traffic patterns for monitoring and modeling?
Practical Decisions in Monitoring and Modeling

1. Purpose, goal for monitoring
2. Monitoring locations (system/network, trails, segments, reference and short-duration sites)
3. Monitoring technologies
4. Quality assurance/quality control procedures
5. Analytics methods (factor groups, correction factors, factoring method)
6. Modeling procedures (land use regressions)
7. Resources to sustain and improve
# Trail Monitoring in Minneapolis

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Purpose</strong></td>
<td>Estimates of average annual daily trail traffic, miles traveled (mixed mode = bikes &amp; peds)</td>
</tr>
<tr>
<td><strong>2. Locations</strong></td>
<td>6 reference sites, 76 short-duration locations</td>
</tr>
<tr>
<td><strong>3. Technologies</strong></td>
<td>Trail Master Active Infrared Counters (&amp; inductive loops)</td>
</tr>
<tr>
<td><strong>4. QA/QC</strong></td>
<td>On-site calibration, outliers, correction for occlusion, systematic error</td>
</tr>
<tr>
<td><strong>5. Analytics</strong></td>
<td>Two-step factoring, day-of-year factors</td>
</tr>
<tr>
<td><strong>6. Modeling</strong></td>
<td>Negative binomial land use regression, weather controls</td>
</tr>
<tr>
<td><strong>7. Sustainability</strong></td>
<td>Collaboration, scrambling</td>
</tr>
</tbody>
</table>
Automated Traffic Monitoring on Multiuse Trails in Minneapolis

Typical Monitoring Site: Midtown Greenway
Trail Segments for Short-Duration Counts

Descriptive statistics
- No. of segments = 80
- Sum = 78.3 miles
- Mean = 0.98 miles
- Minimum = 0.17 miles
- Maximum = 1.8 miles

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

- 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

- 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

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

Inductive Loop: Bicycles

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

\[ y = 1.0328x \]
\[ y = 0.7018x \]
## Correction Equations for Automated Counters by Mode

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

$y = \text{estimated hourly traffic}; \ x = \text{hourly count from monitor}$
## Average Annual Daily Bicycle & Pedestrian Traffic

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

Monthly mean daily traffic

Mixed mode traffic varied by an order of magnitude across sites.

Monthly/annual mean daily traffic ratios generally were consistent across sites.

Bicycle traffic is characterized by greater seasonality than pedestrian 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: recreational and “utilitarian” trail sites

Peds: recreational and “utilitarian” trail sites
Weekday and Weekend Hourly Traffic (%)

Midtown Greenway Hennepin

Lake Calhoun Trail

Note: Friday similarities to weekend at lake trail
Adjustment Factors for Short-duration Counts: Day-of-Week, Month-of-Year vs. Day-of-Year
Day-of-Year Factors Reduce Extrapolation Error

- Mean absolute AADT error vs. Number of short-duration sampling days
- Old scaling method
- New scaling method
- Counters needed

Graph shows the reduction in mean absolute AADT error and the number of counters needed with increasing number of short-duration sampling days.
Sampling from April to October Minimizes Extrapolation Error

![Graphs showing the comparison between new and old scaling methods for different short-duration counts from January to December.](image)
### Average Annual Daily Trail Traffic

<table>
<thead>
<tr>
<th>Segment</th>
<th>AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>954</td>
</tr>
<tr>
<td>Median</td>
<td>750</td>
</tr>
<tr>
<td>Max</td>
<td>3,728</td>
</tr>
<tr>
<td>P90</td>
<td>2,321</td>
</tr>
<tr>
<td>P75</td>
<td>1,264</td>
</tr>
<tr>
<td>P25</td>
<td>142</td>
</tr>
<tr>
<td>P10</td>
<td>81</td>
</tr>
<tr>
<td>Min</td>
<td>39</td>
</tr>
</tbody>
</table>
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 factor groups. Need new reference monitoring sites.
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
- Adjustment factors enable extrapolation of short duration counts (day-of-year better)
- Can estimate miles traveled on trail network
- Need to reconfigure reference sites
Estimating Modeling from Counts

- **Objective**
  - Estimate daily mixed-mode traffic on multiuse trails

- **Approach**
  - Daily traffic volume =
    - Weather
    - Neighborhood socio-demographics
    - Urban form and built environment
    - Transportation infrastructure
## Modeling Mixed Mode Daily Trail Traffic

<table>
<thead>
<tr>
<th>Variables</th>
<th>Expected Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neighborhood Socio-demographic Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>African American residents (%)</td>
<td>-</td>
</tr>
<tr>
<td>Residents with college degrees (%)</td>
<td>+</td>
</tr>
<tr>
<td>Population over 64 or below 6 (%)</td>
<td>-</td>
</tr>
<tr>
<td>Median household income. (1,000 dollars)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Neighborhood Built Environment</strong></td>
<td></td>
</tr>
<tr>
<td>Population density (per square kilometer).</td>
<td>+</td>
</tr>
<tr>
<td><strong>Weather Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>Recorded high temperature.(in Celsius)</td>
<td>+</td>
</tr>
<tr>
<td>Deviation from the 30-year normal temperature</td>
<td>+/-</td>
</tr>
<tr>
<td>Precipitation.(centimeters)</td>
<td>-</td>
</tr>
<tr>
<td>Average wind speed. (kph)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Temporal Dummies</strong></td>
<td></td>
</tr>
<tr>
<td>Saturday or Sunday (equals 1, otherwise 0)</td>
<td>+</td>
</tr>
</tbody>
</table>
Modeling Mixed-mode Trail Traffic
(Wang et al. 2013)
### Modeling Choices Affect Accuracy of Estimates

<table>
<thead>
<tr>
<th>Site</th>
<th>Model Type</th>
<th>Mean Daily Traffic</th>
<th>Land Use Model General</th>
<th>Six Location Model</th>
<th>Trail Specific Models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Predict</td>
<td>Error</td>
<td>Predict</td>
</tr>
<tr>
<td>Hennepin</td>
<td>NB2</td>
<td>2496</td>
<td>2393</td>
<td>8.3</td>
<td>2271</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
<td></td>
<td>2703</td>
<td>19.4</td>
<td>2670</td>
</tr>
<tr>
<td>WRP</td>
<td>NB2</td>
<td>1188</td>
<td>1014</td>
<td>17.2</td>
<td>1017</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
<td></td>
<td>1454</td>
<td>27.3</td>
<td>1458</td>
</tr>
<tr>
<td>Cedar</td>
<td>NB2</td>
<td>2871</td>
<td>2606</td>
<td>13.8</td>
<td>2610</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
<td></td>
<td>2730</td>
<td>10.1</td>
<td>2732</td>
</tr>
<tr>
<td>Calhoun</td>
<td>NB2</td>
<td>4103</td>
<td>3649</td>
<td>20.7</td>
<td>3679</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
<td></td>
<td>4033</td>
<td>44.1</td>
<td>4037</td>
</tr>
<tr>
<td>Nokomis</td>
<td>NB2</td>
<td>1430</td>
<td>1689</td>
<td>22.5</td>
<td>1703</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
<td></td>
<td>2082</td>
<td>55.9</td>
<td>2085</td>
</tr>
<tr>
<td>Wirth</td>
<td>NB2</td>
<td>419</td>
<td>338</td>
<td>17.4</td>
<td>342</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
<td></td>
<td>1048</td>
<td>151.5</td>
<td>1051</td>
</tr>
<tr>
<td>Grand Mean Error NB (%)</td>
<td>16.6</td>
<td>17.1</td>
<td>15.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Mean Error OLS (%)</td>
<td>51.4</td>
<td>51.5</td>
<td>27.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Observations from Modeling

• Possible to identify factors associated with higher non-motorized trail volumes
• Trail models do reasonable job estimating volumes (+ 15-20%)
• Modeling choices affect accuracy
• Models can be improved with better specification and additional data
TMAP Trail Monitoring: Building on Experience

| 1. Purpose          | • Develop national trail model, factors for all climatic regions  
                        • Estimates of average annual daily trail traffic, miles traveled |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>2. Locations</td>
<td>• 9 regions, 10-12 cities, 25-30 locations</td>
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<tr>
<td>3. Technologies</td>
<td>• Eco-multi counters (inductive loop and passive infrared, separate bike and ped counts)</td>
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<td>4. QA/QC</td>
<td>• On-site calibration, outliers, correction for occlusion, systematic error</td>
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<tr>
<td>5. Analytics</td>
<td>• Two-step factoring, day-of-year factors</td>
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<tr>
<td>6. Modeling</td>
<td>• Negative binomial land use regression, weather controls</td>
</tr>
<tr>
<td>7. Sustainability</td>
<td>• Collaboration, local partners</td>
</tr>
</tbody>
</table>
Questions?

For more information contact:

Greg Lindsey (linds301@umn.edu)
Bicycle Network Analysis
Active Living Research Conference 2014
Mike Lowry, University of Idaho
Outline


3. Prioritizing projects based on connectivity.
CONDUCTING CITIZEN-VOLUNTEER COUNT PROGRAMS
4 Movement Toward Intersection

4 Movement Leaving Intersection

12 Movement

2 Movement Screenline
Screenline Additional
-Helmet/No Helmet
-Male/Female
-Adult/Child
-Street/Sidewalk
# Citizen Volunteer Counts

## 2012 Washington State Bicycle and Pedestrian Documentation Project

### Table 2: Count cities and locations by year

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</tr>
</tbody>
</table>

### Map

The map shows the locations of volunteer counts across various cities in Washington State. The red dots indicate areas where counts were conducted.
Count Dates:
The next count/survey days are May 6-8, 2014. Upcoming days through 2014 are:
- May 5-8, 2014
- July 4-6, 2014
- Sept 9-14, 2014
Stay tuned for the next round of count days!

About
One of the greatest challenges facing the bicycle and pedestrian field is the lack of documentation on usage and demand. Without accurate and consistent demand and usage figures, it is difficult to measure the positive benefits of investments in these modes, especially when compared to the other transportation modes such as the private automobile. An answer to this need for data is the National Bicycle & Pedestrian Documentation Project, co-sponsored by Alta Planning and Design and the Institute of Transportation Engineers (ITE) Pedestrian and Bicycle Council. This nationwide effort provides consistent model of data collection and ongoing data for use by planners, governments, and bicycle and pedestrian professionals.

Methodology
The basic assumptions of the methodology are that, in order to estimate existing and future bicycle and pedestrian demand and activity, agencies nationwide need to start conducting counts and surveys in a consistent manner similar to those being used by ITE and other groups for motor vehicle models.

NBPD to Provide Free Summary Reports!
The National Bicycle and Pedestrian Documentation Project has developed a summary report that highlights the valuable information that can be gained from year-long automatic bicycle and pedestrian counts. If your community uses Eco-Counter automatic count technology, the National Bicycle and Pedestrian Documentation Project will provide a free summary report of the data in exchange for submission of the annual automatic count data to the project. This report puts valuable information regarding usage and trends at your fingertips which can be used in grant applications, press releases, annual count reports, etc. Sample reports are available here and here. Email your Eco-Counter data in excel format to data@bikepedocumentation.org. Please indicate the exact location of the automatic counter and tell us a bit about the bicycle or pedestrian facility.

News
- Adjustment Factors Available: Adjustment factors are now available in an Excel format! While more year-long automatic count data is needed from different parts of the country and various types of facilities, we have a robust selection of data for you.
Instructions

The other dates were selected to provide a representative sampling of activity during a typical spring (May) and winter (January) period. The 4th of July period was selected because it will afford both a typical summer weekday and what is typically the busiest holiday period and activity period for recreational facilities and activities.

Having an official count week is also important for generating interest and the date. Much like the nationwide Bike to Work Weeks, we have that the National Pedestrian Documentation Project Week in September will become a much-anticipated annual event in localities around the nation.

Times
Based on our research, we are recommending weekends. However, if you have been doing using these same time periods for all events.

Rationale for Time Periods
Time periods are more important for count periods when there are consistent travel trends. School activities conducted during these periods will provide a good sampling of peak traffic periods.

Automatic Counts
While the NHTF is based on manual counts, conducting counts to consider the increase in count period.

Weather
Weather may be a determinant in selecting count periods and surveys, but a particular poor or unusual during the count period.

Forms

The National Bicycle and Pedestrian Documentation Project

How do you count this?

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Recommendations

• Create your own forms
• Enhance the training
• Customize the experience
• Define the purpose and stay focused
<table>
<thead>
<tr>
<th>Purpose</th>
<th>Yes/No/Maybe</th>
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</thead>
<tbody>
<tr>
<td>Raising awareness about bicycle and pedestrian activity</td>
<td>Yes</td>
</tr>
<tr>
<td>Providing public engagement and outreach</td>
<td>Yes</td>
</tr>
<tr>
<td>Getting a snap shot of community-wide biking/walking</td>
<td>Yes</td>
</tr>
<tr>
<td>Applying for grants</td>
<td>Yes</td>
</tr>
<tr>
<td>Analyzing trends year-to-year</td>
<td>No</td>
</tr>
<tr>
<td>Making comparisons with other communities</td>
<td>No</td>
</tr>
<tr>
<td>Determining percentage of bicycle and pedestrian travel</td>
<td>No</td>
</tr>
<tr>
<td>Making adjustments to traffic signal timing</td>
<td>Yes</td>
</tr>
<tr>
<td>Improving signage</td>
<td>Yes</td>
</tr>
<tr>
<td>Making infrastructure improvements</td>
<td>Yes</td>
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<tr>
<td>Improving paint markings</td>
<td>Yes</td>
</tr>
<tr>
<td>Safety analysis</td>
<td>Yes</td>
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<tr>
<td>Project selection</td>
<td>Yes</td>
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<td>Project evaluation (before and after studies)</td>
<td>Maybe</td>
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<tr>
<td>Identifying bike/ped characteristics (Helmet/No Helmet etc.)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Purpose?**
80 locations!
• 26 Locations
• 7:00 – 9:00 AM
• 4:00 – 6:00 PM
341 locations

Three day tube counters for cars
<table>
<thead>
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<td>5:30-5:45 PM</td>
<td>NBL</td>
<td>Pedestrian</td>
<td>0</td>
</tr>
<tr>
<td>10/10/2013</td>
<td>5:30-5:45 PM</td>
<td>NBT</td>
<td>Pedestrian</td>
<td>0</td>
</tr>
<tr>
<td>10/10/2013</td>
<td>5:30-5:45 PM</td>
<td>NBR</td>
<td>Pedestrian</td>
<td>0</td>
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<tr>
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<td>5:30-5:45 PM</td>
<td>WBL</td>
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<td>5:30-5:45 PM</td>
<td>WBT</td>
<td>Pedestrian</td>
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<tr>
<td>10/10/2013</td>
<td>5:30-5:45 PM</td>
<td>SBR</td>
<td>Bicycle</td>
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<tr>
<td>10/10/2013</td>
<td>5:30-5:45 PM</td>
<td>SBT</td>
<td>Bicycle</td>
<td>0</td>
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<tr>
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<td>5:30-5:45 PM</td>
<td>SBL</td>
<td>Bicycle</td>
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<td>Bicycle</td>
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<tr>
<td>10/10/2013</td>
<td>5:30-5:45 PM</td>
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<td>Bicycle</td>
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<tr>
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<td>5:30-5:45 PM</td>
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</table>

**iCount Data Entry Form**

**Numerical Date 01/01/2011:**

**Date:**

**Select 15 Minute Increment:**

**Morning Shift:**
- 7:00 - 7:15 AM
- 7:15 - 7:30 AM
- 7:30 - 7:45 AM
- 7:45 - 8:00 AM
- 8:00 - 8:15 AM
- 8:15 - 8:30 AM
- 8:30 - 8:45 AM
- 8:45 - 9:00 AM

**Evening Shift:**
- 4:00 - 4:15 PM
- 4:15 - 4:30 PM
- 4:30 - 4:45 PM
- 4:45 - 5:00 PM
- 5:00 - 5:15 PM
- 5:15 - 5:30 PM
- 5:30 - 5:45 PM
- 5:45 - 6:00 PM

**Bike:**
- 0
- 0
- 0
- 0
- 0
- 0
- 0
- 0

**Ped:**
- 0
- 0
- 0
- 0
- 0
- 0
- 0
- 0

**Other:**
- 0
- 0
- 0
- 0
- 0
- 0
- 0
- 0

**Clear Form Data**
**Submit Data**
**Close**
[Data Entry and Mapping Demonstration video]

http://www.youtube.com/watch?v=Nx2BtHDaRbE
ESTIMATING NETWORK-WIDE BICYCLE VOLUMES
[Volume Estimation Demonstration video]

http://www.youtube.com/watch?v=dMp2XIQaykw
Step 1. Spatially Extrapolate

AM 2 Hour Volume

PM 2 Hour Volume

$\left[ \frac{V_{AM}}{k_{AM}} + \frac{V_{PM}}{k_{PM}} \right] / 2 \times F_{day} \times F_{month} = AADB$

Step 2. Temporally Extrapolate

AADB
### Scenario Planning

#### Third Street Bicycle Volumes Existing and Forecasted

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<th>Existing Conditions (AADB)</th>
<th>Proposed Scenario (AADB)</th>
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<td>Harrison Street</td>
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<tr>
<td>Tyler Street</td>
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<td>Fillmore Street</td>
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<tr>
<td>Pierce Street</td>
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<td>255</td>
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</table>

*Increase of about 200 bicyclists per day.*

*Increase of about 150 bicyclists per day.*
PRIORITIZING PROJECTS BASED ON CONNECTIVITY
- **Bicycle Suitability**
  Perceived comfort and safety of a segment of street or pathway

- **Bikeability**
  Perceived comfort and safety of network connectivity for accessing important destinations

- **Bicycle Friendliness**
  Perceived comfort and safety of all aspects of bicycle travel, including bikeability, laws and policies to promote bicycling, education efforts to encourage bicycling, and general acceptance of bicycling throughout the community
<table>
<thead>
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<th>Name of Method</th>
<th>Acronym</th>
<th>Author</th>
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<td>Davis</td>
<td>1987</td>
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<td>Bicycle Stress Level</td>
<td>BSL</td>
<td>Sorton and Walsh</td>
<td>1994</td>
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<td>Road Condition Index</td>
<td>RCI</td>
<td>Epperson</td>
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<td>Interaction Hazard Score</td>
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<td>Botma</td>
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<td>Turner et al</td>
<td>1997</td>
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<td>BCI</td>
<td>Harkey et al</td>
<td>1998</td>
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<td>Emery and Crump</td>
<td>2003</td>
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<td>RBCI</td>
<td>Jones</td>
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<tr>
<td>Compatibility of Roads for Cyclists</td>
<td>CRC</td>
<td>Noel et al</td>
<td>2003</td>
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<td>SFDPH</td>
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<td>Birk et al</td>
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<td>HCM</td>
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<td>Bicycle Levels of Traffic Stress</td>
<td>LTS</td>
<td>Mekuria and Furth</td>
<td>2012</td>
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**Equation**

\[
Bicycle \ Level \ of \ Service = 0.76 + [-0.005(w_{ol} + w_{bl} + w_{os})(2 - 0.005v) + (w_{bl} + w_{os} - 20p_{pk}) - 1.5c)^2] \\
\quad + 0.507 \ln\left(\frac{v}{4N_{th}}\right) \\
\quad + 0.199[1.119 \ln(S - 20) + 0.8103][1 + 0.1038P_{HV}]^2 + 7.066\left(\frac{1}{P_c^2}\right)
\]

**Input**

<table>
<thead>
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<th>Attribute</th>
<th>Description</th>
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<tbody>
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<td>w_{ol}</td>
<td>width of outside lane (ft)</td>
</tr>
<tr>
<td>w_{bl}</td>
<td>width of bike lane (ft)</td>
</tr>
<tr>
<td>w_{os}</td>
<td>width of outside shoulder including parking and gutter (ft)</td>
</tr>
<tr>
<td>p_{pk}</td>
<td>estimated proportion of on-street parking that would be occupied during analysis period (decimal)</td>
</tr>
<tr>
<td>c</td>
<td>curb present (yes = 1, no = 0)</td>
</tr>
<tr>
<td>v</td>
<td>directional analysis period vehicle volume (vph)</td>
</tr>
<tr>
<td>N_{th}</td>
<td>number of through lanes (#)</td>
</tr>
<tr>
<td>S</td>
<td>average vehicle speed (mph)</td>
</tr>
<tr>
<td>PHV</td>
<td>percent heavy vehicles (decimal)</td>
</tr>
<tr>
<td>P_c</td>
<td>pavement condition (poor-excellent) (0-5)</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>BLOS</th>
<th>Letter Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2.00</td>
<td>A</td>
</tr>
<tr>
<td>2.00-2.75</td>
<td>B</td>
</tr>
<tr>
<td>2.75-3.50</td>
<td>C</td>
</tr>
<tr>
<td>3.50-4.25</td>
<td>D</td>
</tr>
<tr>
<td>4.25-5.00</td>
<td>E</td>
</tr>
<tr>
<td>&gt;5.00</td>
<td>F</td>
</tr>
</tbody>
</table>
[BLOS Demonstration video]

http://www.youtube.com/watch?v=k3ch1J9ugmM
Great Bicycle Suitability...

...But does it go anywhere?
• **Bicycle Suitability**
  Perceived comfort and safety of a segment of street or pathway

• **Bikeability**
  Perceived comfort and safety of network connectivity for accessing important destinations

• **Bicycle Friendliness**
  Perceived comfort and safety of all aspects of bicycle travel, including bikeability, laws and policies to promote bicycling, education efforts to encourage bicycling, and general acceptance of bicycling throughout the community
[Bikeability Demonstration video]

http://www.youtube.com/watch?v=2Wi14vy7ZU4
CONCLUSION
Exciting progress...

- Explosion of citizen-volunteer programs...
- Promising new GIS tools...
- Rails-to-Trails is working on connectivity!
Thank you...

...Questions??

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