Challenges in Monitoring Regional Trail Use

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Acknowledgments:

- Rails to Trails Conservancy
- Industrial Heartland Trails Coalition

Outline

- Research objectives / project background
- Sampling and monitoring methods
- Data quality management (QAQC)
- Modeling daily traffic
- Monthly factors by land use
- Performance indicators (ADTT, Trail Miles Traveled)
- Conclusions

Research Objectives

- Illustrate application of FHWA *Traffic Monitoring Guide* methods to regional trails
- Estimate performance indicators for 972 mile trail network in 4-state region
- Help design long-term monitoring plans
- Describe implications for practice

FHWA *Traffic Monitoring Guide*

- Establish monitoring objectives
- Determine modes of traffic to monitor
- Select monitoring sites in network
  - Permanent stations (determine patterns and adjustment factors)
  - Short-duration stations (long-term sampling)
- Determine monitoring devices
- Implement monitoring
- Apply QA/QC procedures
- Develop ratios or adjustment factors
- Estimate annual average daily nonmotorized traffic
- Estimate miles traveled on network

Industrial Heartland Trail Coalition

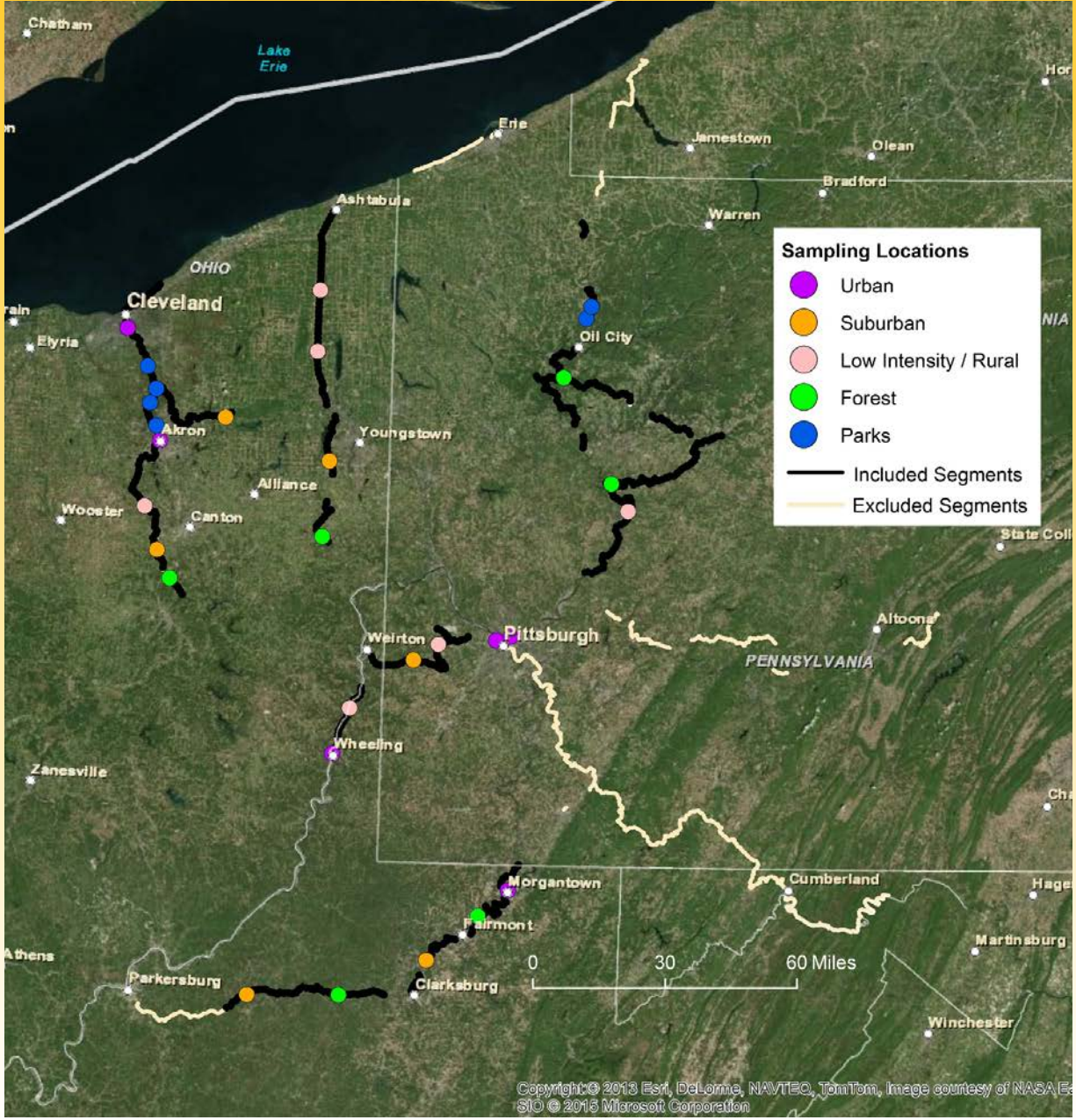
- Regional economic development coalition
  - 100 members
  - Leadership: RTC, National Park Service, and PA Environmental Council
- Trail network
  - Nearly 1000 miles of existing trail
  - Plans to increase network to 1,400 miles
  - 4 states: Ohio, Pennsylvania, W. Virginia, New York
  - 48 counties

RTC / IHTC Project Objectives

- Document **levels** of trail use (subject to budget constraints)
- Document **patterns** of trail use to inform a comprehensive regional monitoring program
- Develop **data and tools** to support IHTC partners in trail planning

Research Team Approach

- Stratified randomized selection of 30 monitoring sites
- Data collection
  - Passive infrared monitors
  - Goal: minimum one year monitoring data (2015-2016)
- Data quality management
  - Visual inspection of data
  - Flag outliers (> 3 standard deviations above mean)
  - Assess zero counts
  - Impute missing values
- Model daily traffic (30 sites, 5 classes, 1 general model)
- Estimate performance indications
  - Annual average daily trail traffic (AADTT); Trail miles traveled (TMT)

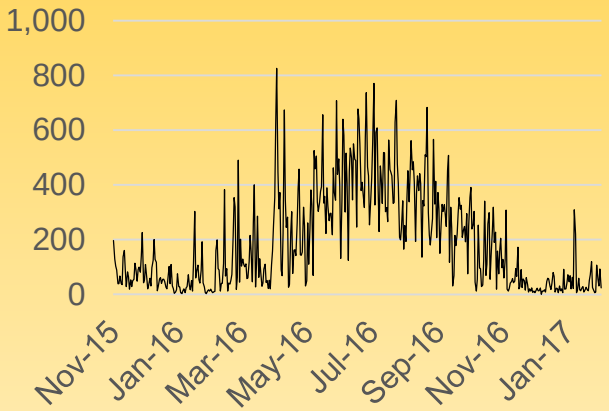


Sampling Approach

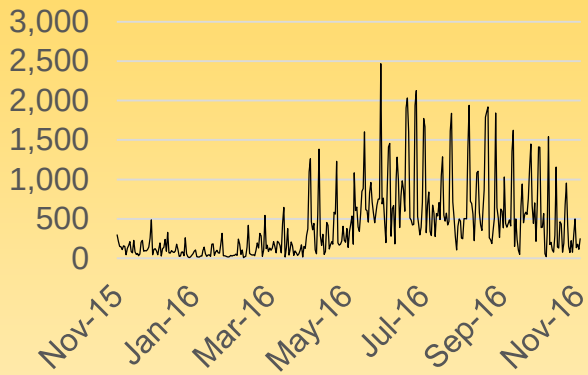
- 30 locations
- Stratified randomized selection of sites
- 1,056 potential sample sites (1 mile intervals in network)
- GIS buffers, 16 factors
- Factor analysis, K-means clustering to identify strata
- Five strata: Urban, suburban, rural, forest, parks

Data Quality Management

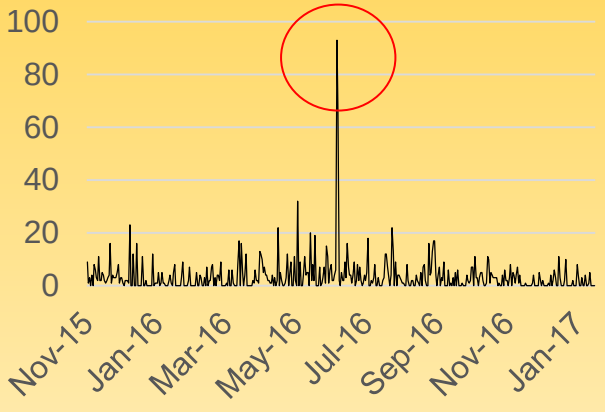
Normal Pattern
Suburban #12



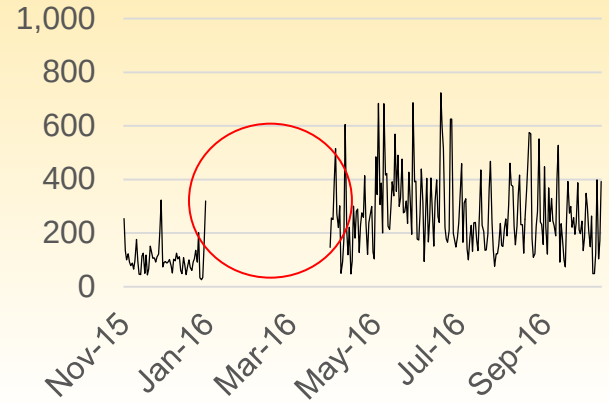
Normal Pattern with Greater Variation
Parks #4



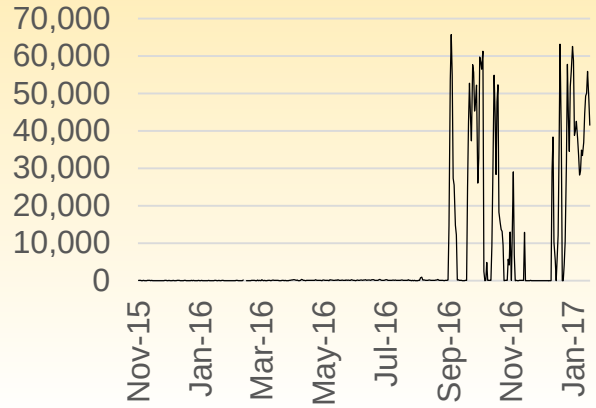
Outliers
Forest #28



Missing Days
Urban #1



Counter with Errors
Suburban #9



- Visual inspection identified problems.
- Missing data.
- Some outliers removed.

Data, QAQC Summary

- 30 monitors deployed
- 22 monitors (73%) deployed ≥ 365 days
- 23 monitors (77%) recorded counts for all days deployed; 7 monitors (23%) had missing days
- 3 monitors included counts judged invalid using QAQC checks
- 19 monitors (63%) had valid counts for ≥ 365 days
- 11 monitors (37%) have valid counts < 365 days (116 – 364 days)
- Total days all monitors deployed: 11,127
- Total days with counts: 10,951 (98% of days deployed)
- Total days with valid counts: 10,698 (96% of days deployed)

Models of Daily Traffic

Negative Binomial Regression Results

All Sites Model	
Dependent variable: ADT	137
Average Dew Point	- - -
Average Wind Speed	+++
Maximum Temperature	+++
Maximum Temperature Squared	+++
Precipitation	- - -
Weekend	+++
Spring	+++
Summer	+++
Fall	+++
Constant	+++
Pseudo R2	0.028

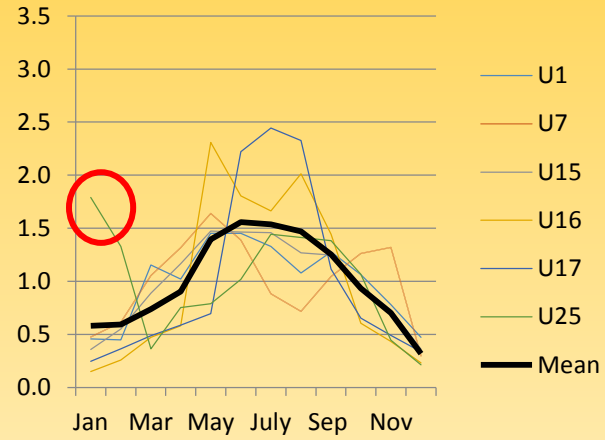
- Site-specific models used to impute missing counts
- All Sites Model (n=10,698)
- All variables significant at 1%
- Similar results, site specific models
- Precipitation is not significant for urban counters
- Dew point is not significant for suburban and forest counters
- Wind speed and max temperature are not significant for rural counters
- Season variables are not significant for parks

Monitoring Results

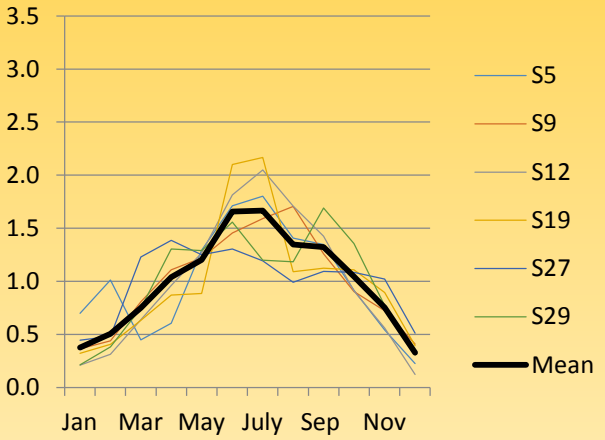
Land Use Strata (6 sites / strata)	Minimum AADTT	Maximum AADTT	Strata Mean AADTT
Forest	4	97	40
Low intensity dev. and rural	20	161	84
Parks	35	597	258
Suburban	31	221	90
Urban	47	506	251

Monthly Factors by Land Use

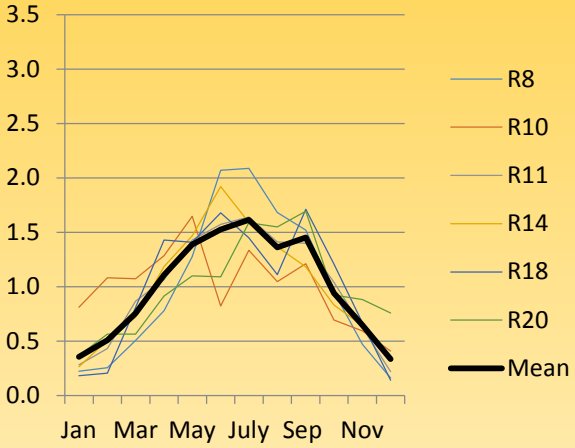
Urban



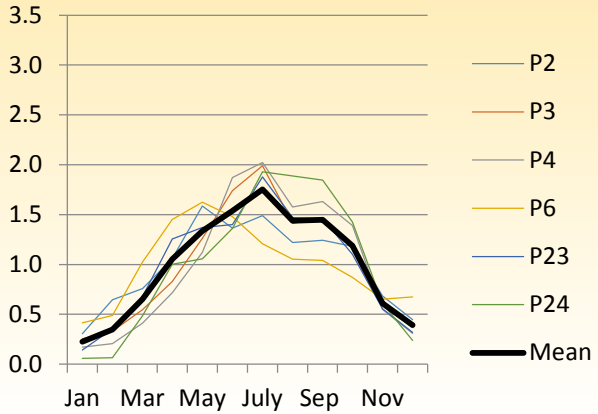
Suburban



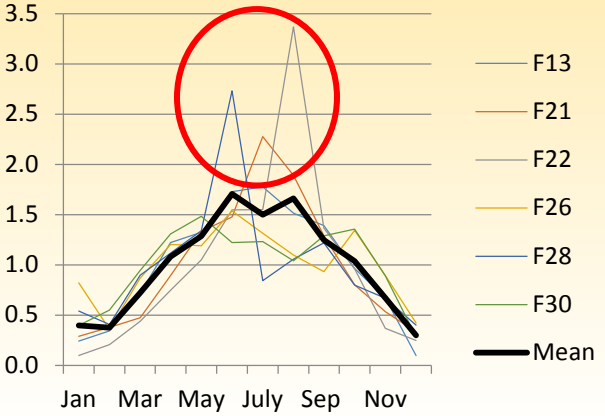
Rural



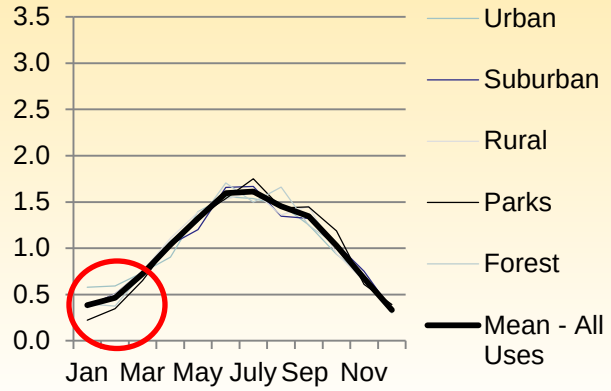
Parks



Forest



All Sites



Estimation of Performance Indicators

Sample Strata	Number of Sample Points	Estimated Trail Miles	AADT	Estimated Trail Miles Traveled Annually	% of Sample Points (Miles)	% of Miles Traveled
Forest	497	457	40	6,676,000	47%	23%
Low intensity dev. and rural	248	228	84	6,995,000	23%	24%
Parks	72	66	258	6,238,000	7%	21%
Suburban	196	180	90	5,924,000	19%	20%
Urban	43	40	251	3,624,000	4%	12%
Totals	1056	972		29,500,000	100%	100%

Conclusions

- FHWA principles applicable to regional trail monitoring
- Many practical challenges in monitoring
- Stratified-randomized sampling approach is useful
- QAQC procedures essential for valid estimates
- Daily traffic can be modeled using weather, day-of-week, and season variables
- Monthly average daily traffic patterns converge across land uses (regardless of volume)
- Trail traffic volumes (AADTT) associated with adjacent land use
- Trail miles traveled substantial: 29.5 million miles / year

Next Steps

- Characterize uncertainty in estimates
- Complete analysis of traffic patterns (e.g., recreation, commuting, multipurpose)
- Compute time-of-day and day-of-week factors
- Design short-duration monitoring program
- Refine, track performance indicators

Questions?

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