Estimating Pedestrian and Bicycle Miles Traveled (PMT/BMT) in Washington State

Krista Nordback, P.E., Ph.D.

Mike Sellinger, MURP

Taylor Phillips

Portland State UNIVERSITY

TREC

Overview

- Purpose & Scope
- Review
- Data
- Methods
- Results
- Conclusions & Recommendations
- Next Steps

PURPOSE

Motivation
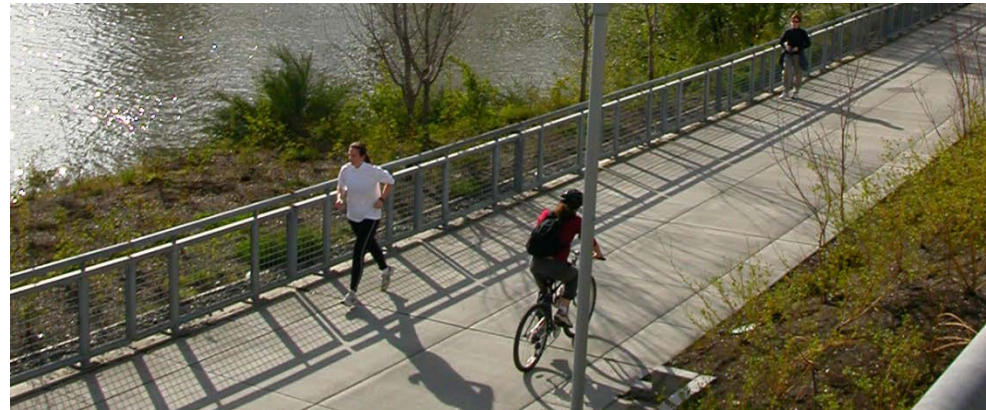
VMT is an accepted metric for motorized travel.

A comparable metric is needed for walking and cycling. Needed by

- Policy makers
- Engineers
- Planners
- Researchers

Why measure walking & biking?

- Funding & policy decisions
- To show change over time
- Facility design
- Planning (short-term, long-term, regional…)
- Economic impact
- Public health
- Safety

Motivation

SAFETY: Accurate estimation of bicyclist and pedestrian volumes are critical to evidence-based safety analysis of bicycling and walking.

HEALTH:

- Exposure to air pollutants
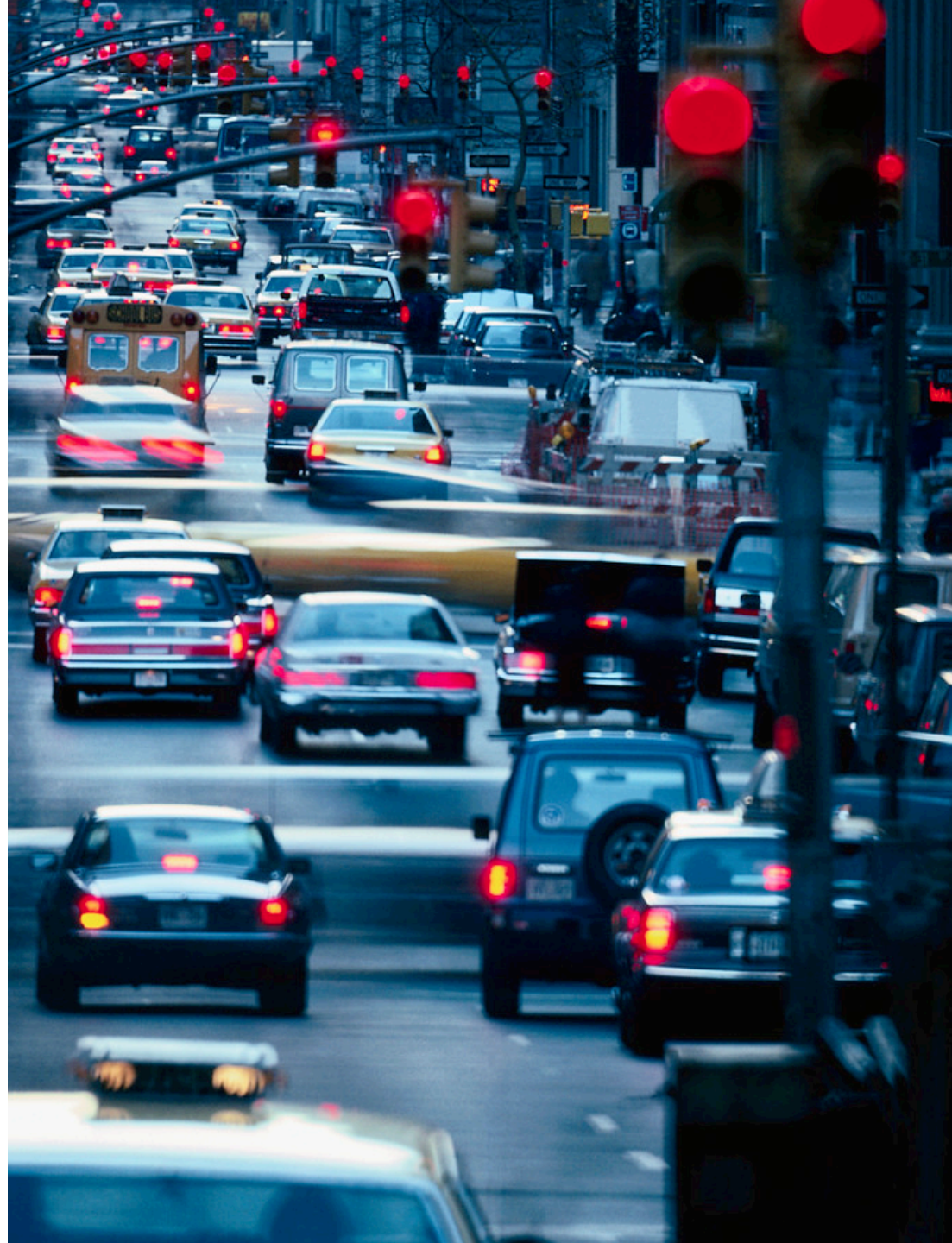- Changes in physical activity

BMT and PMT

- Bicycle Miles Traveled (BMT)
- Pedestrian Miles Traveled (PMT)

REVIEW

TRAFFIC MONITORING PROGRAMS

State Traffic Monitoring

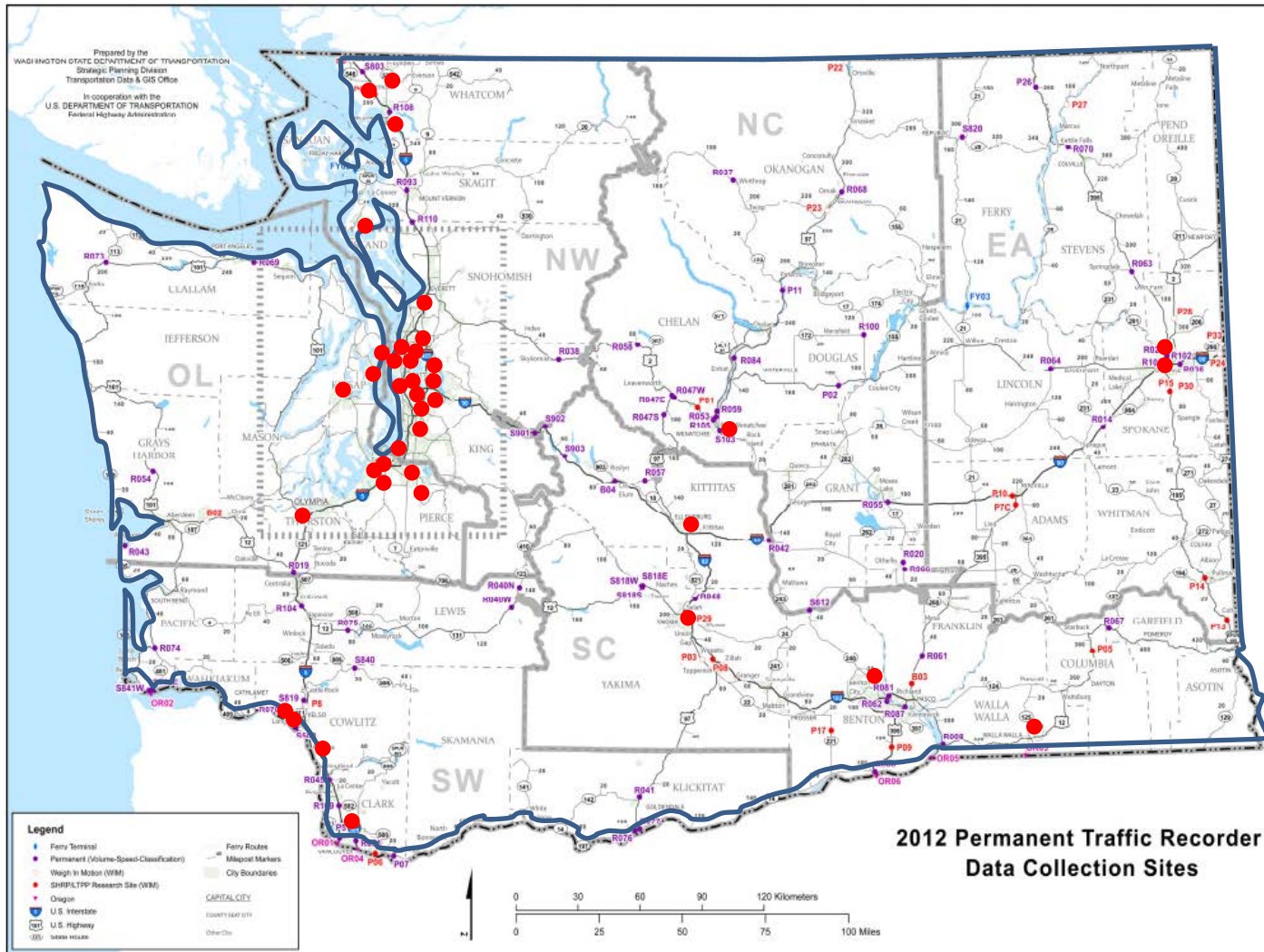## Permanent Counters

Commonly inductive loops

Metro Count Accessed 6/13/13 http://mtehelp.tech-metrocount.com/article.aspx?key=mc5805

Short Duration Counters

Commonly pneumatic tubes

Permanent Counters
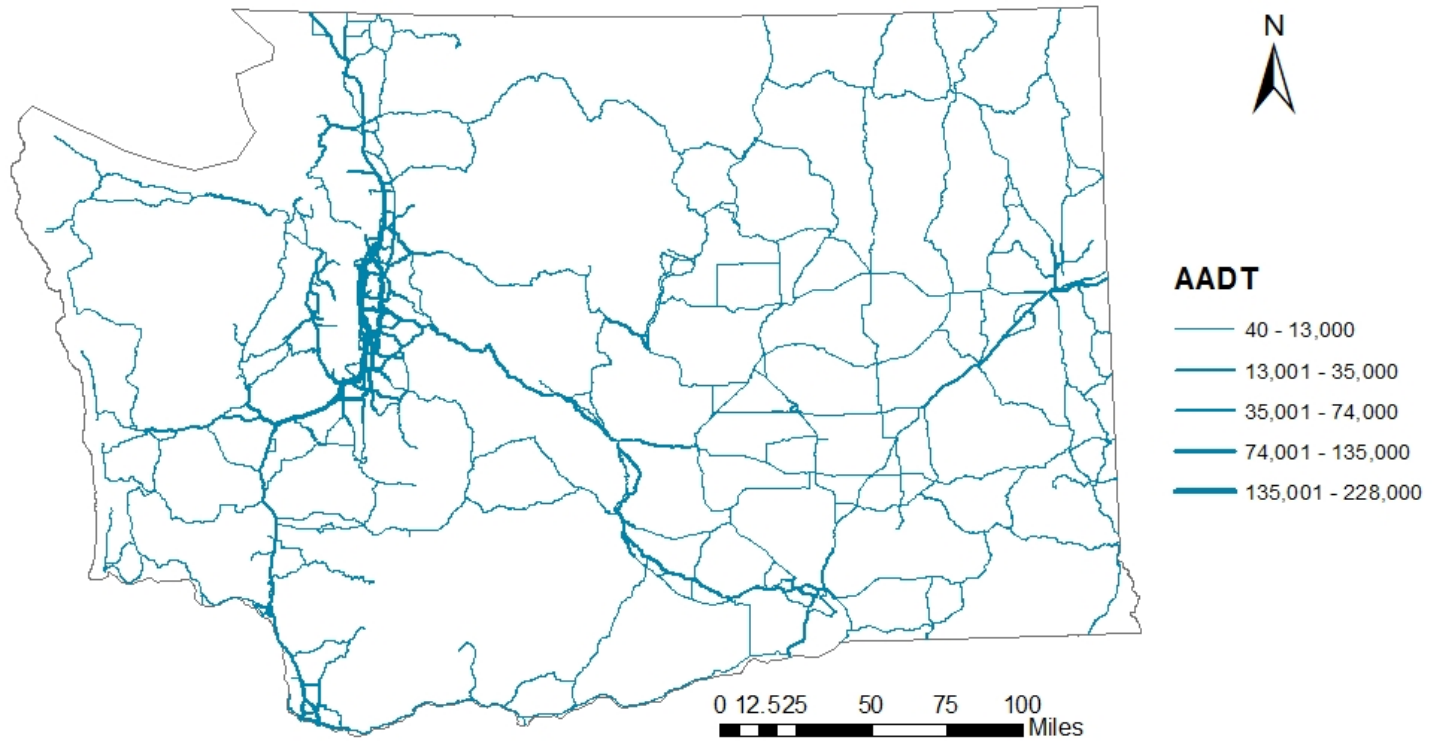

2012 Permanent Traffic Recorder
Data Collection Sites
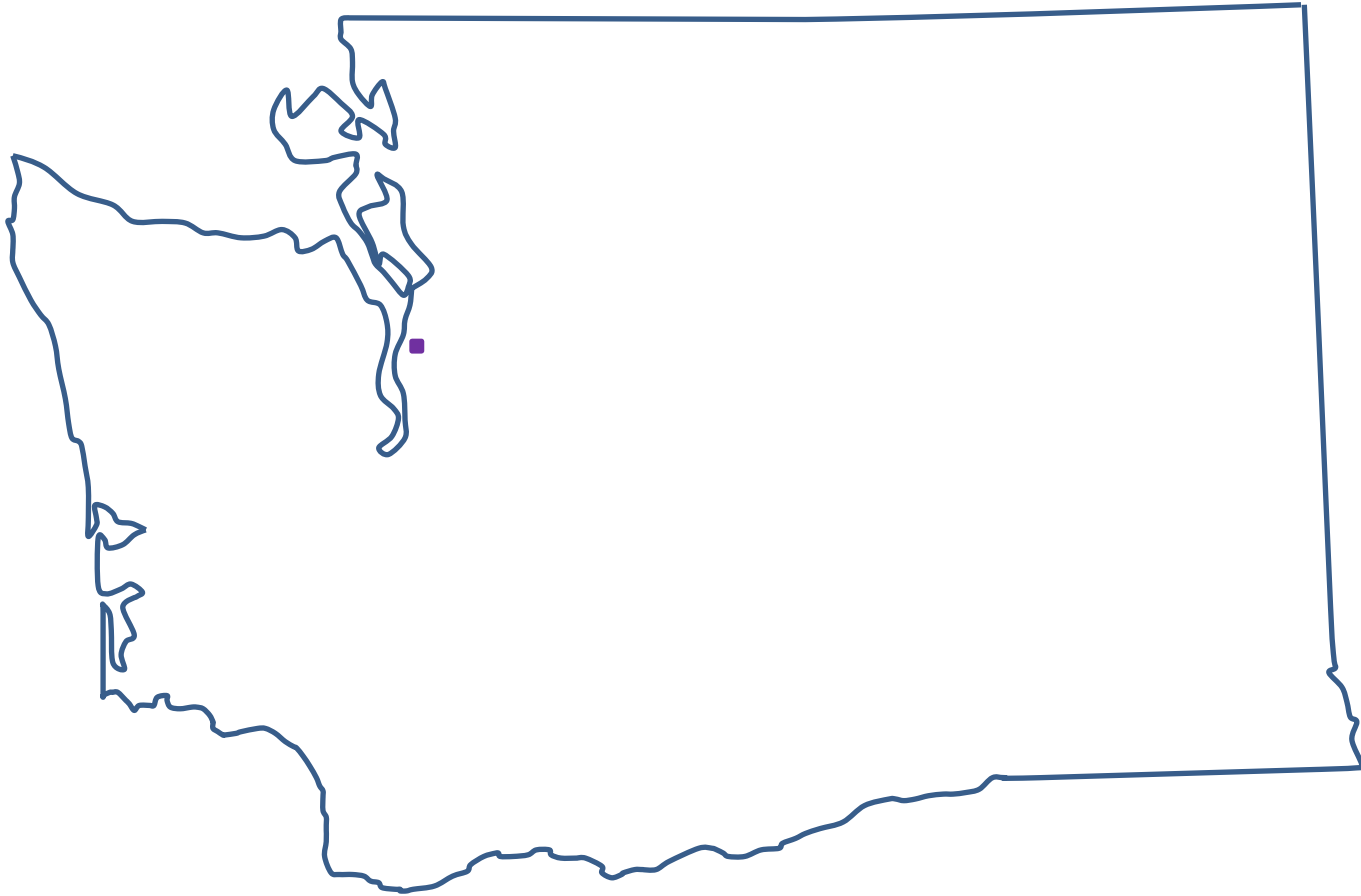
Short Duration Counters
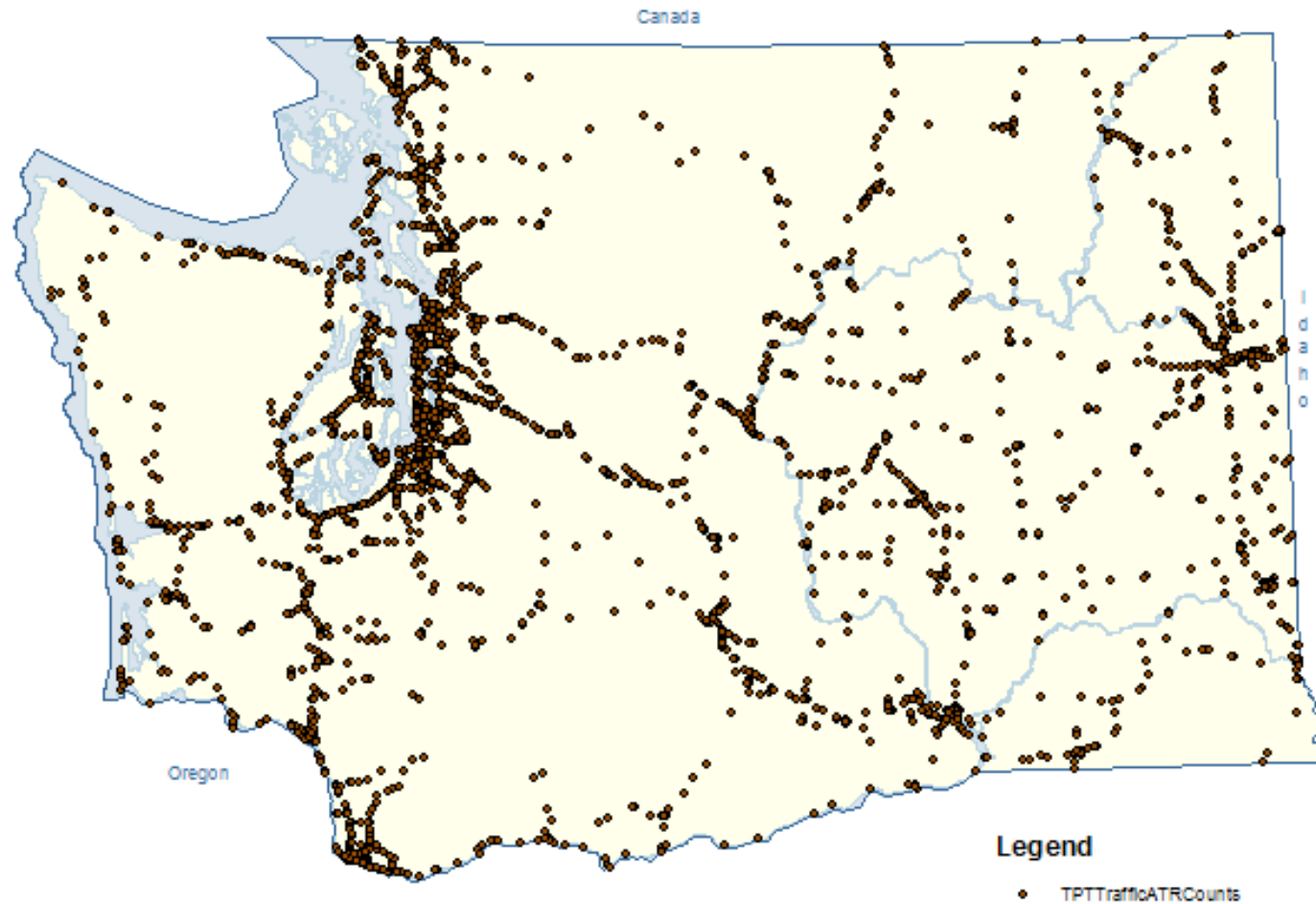
AADT and VMT

Can we apply these methods
to biking and walking?

Permanent Counters in 2012

■ Bicycle Counter

Permanent Counters now?
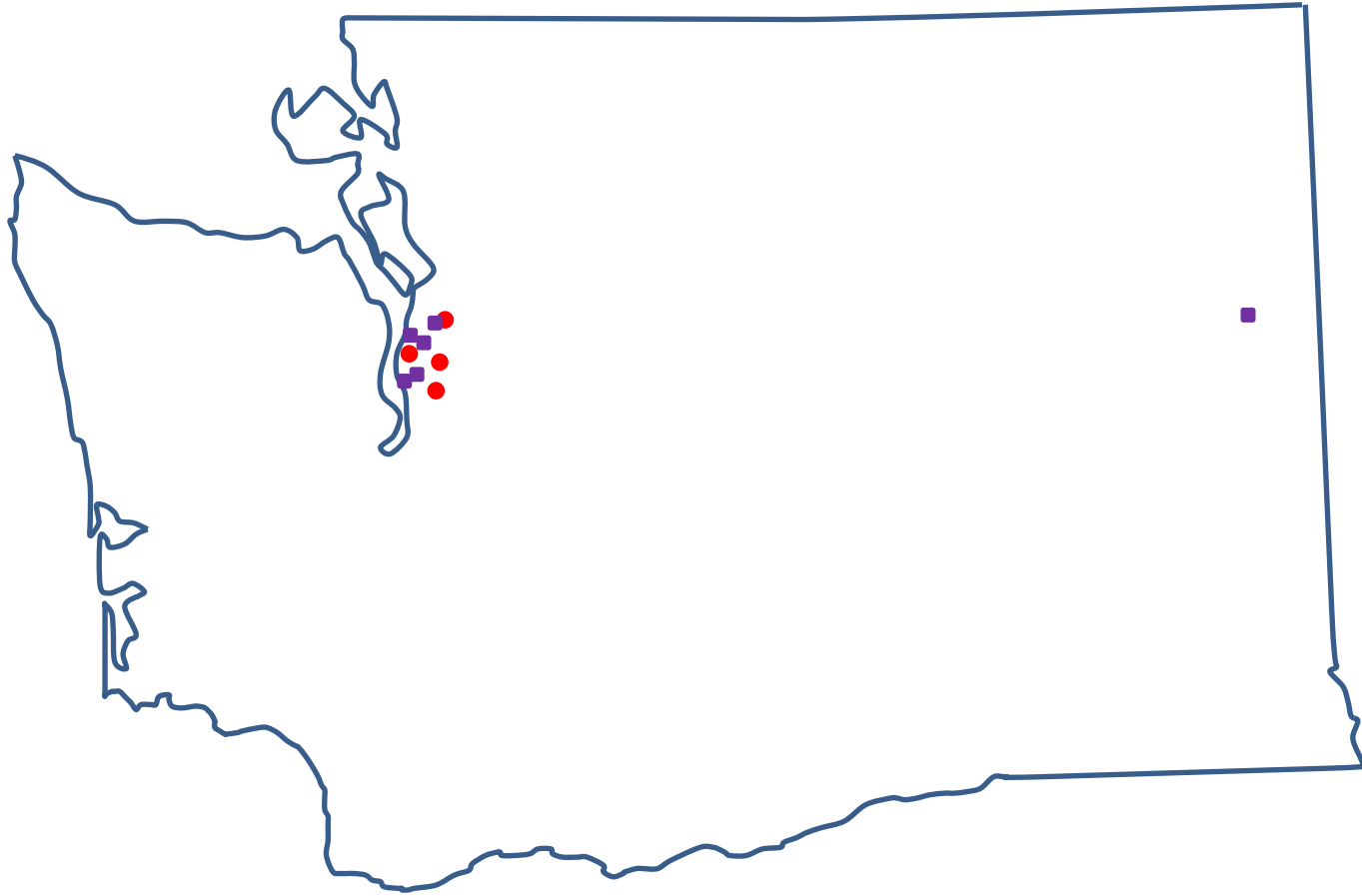
■ Bicycle Counter
● Bicycle and Pedestrian Counter

Short Duration Counts

2012 WASHINGTON STATE BICYCLE AND PEDESTRIAN DOCUMENTATION PROJECT
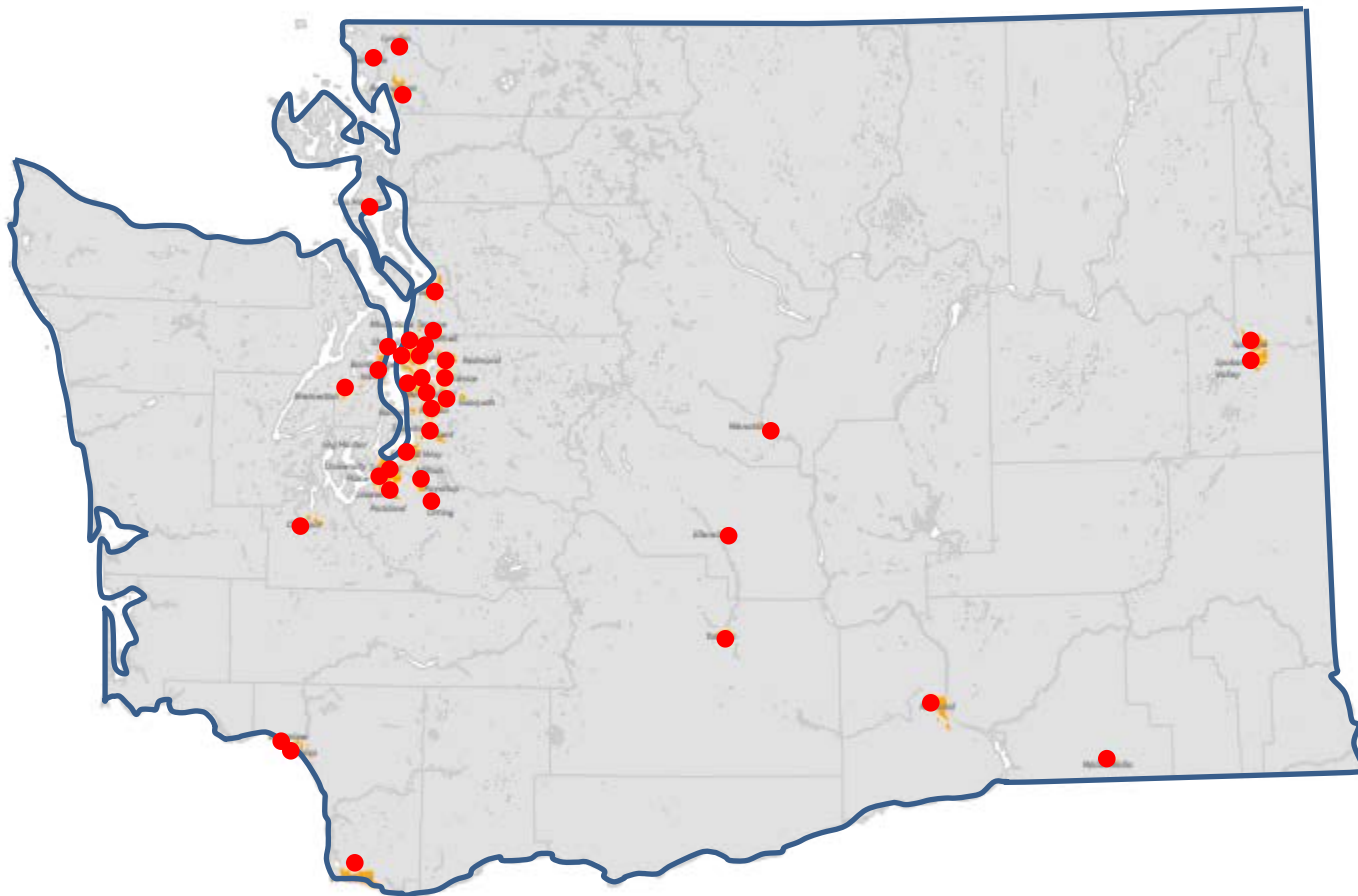
DATA

Non-motorized Data

Volume Data:

Type	Pros	Cons
Survey/travel dairy	Representative sample	No facility level info
GPS	Route choice included	Usually self-selection bias
Continuous and short-term counts	Facility level	Many locations needed

Spatial Variables:

- Facility type, land use, geography
- Socio-demographics, population
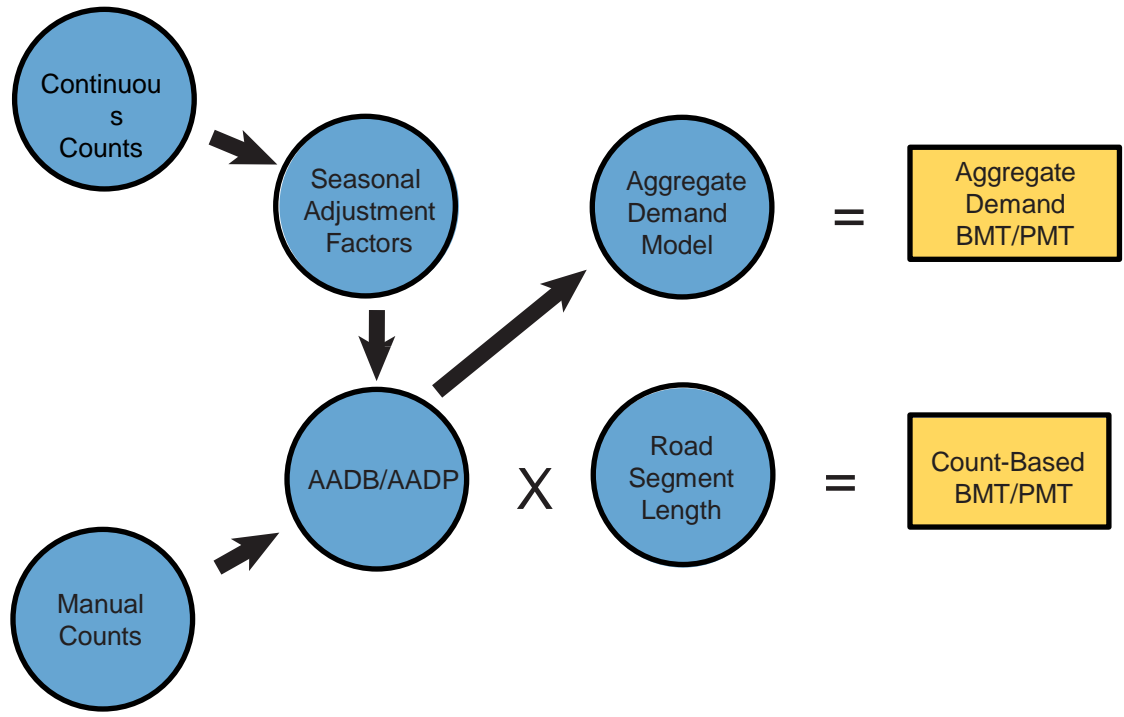
METHODS

Estimating Pedestrian and Bicycle Miles Traveled (PMT/BMT) in Washington State

Pedestrian/Bicycle Volume Estimates

- Sample based approach
- Aggregate demand model
- Travel Surveys

```
Continuous
Counts  →  Seasonal
           Adjustment
           Factors  →  Aggregate
                       Demand
                       Model  =  Aggregate
                                 Demand
                                 BMT/PMT

           AADB/AADP  X  Road
                         Segment
                         Length  =  Count-Based
                                    BMT/PMT
Manual
Counts  →  AADB/AADP
```

Count-based Method

- Stratified Random Sample
  - Where to count?
  - Which strata (attributes) impact bike/ped volumes?

Sampling Groups

Attribute	Recommended Categories	Number of Categories
Level of urbanism	Urban Rural	2
Road or path type	Arterials & highway, Local Roads, Collectors, & Paths	2
Geographic and climatic regions	Coast Range Puget Lowland Cascades Eastern Washington	4
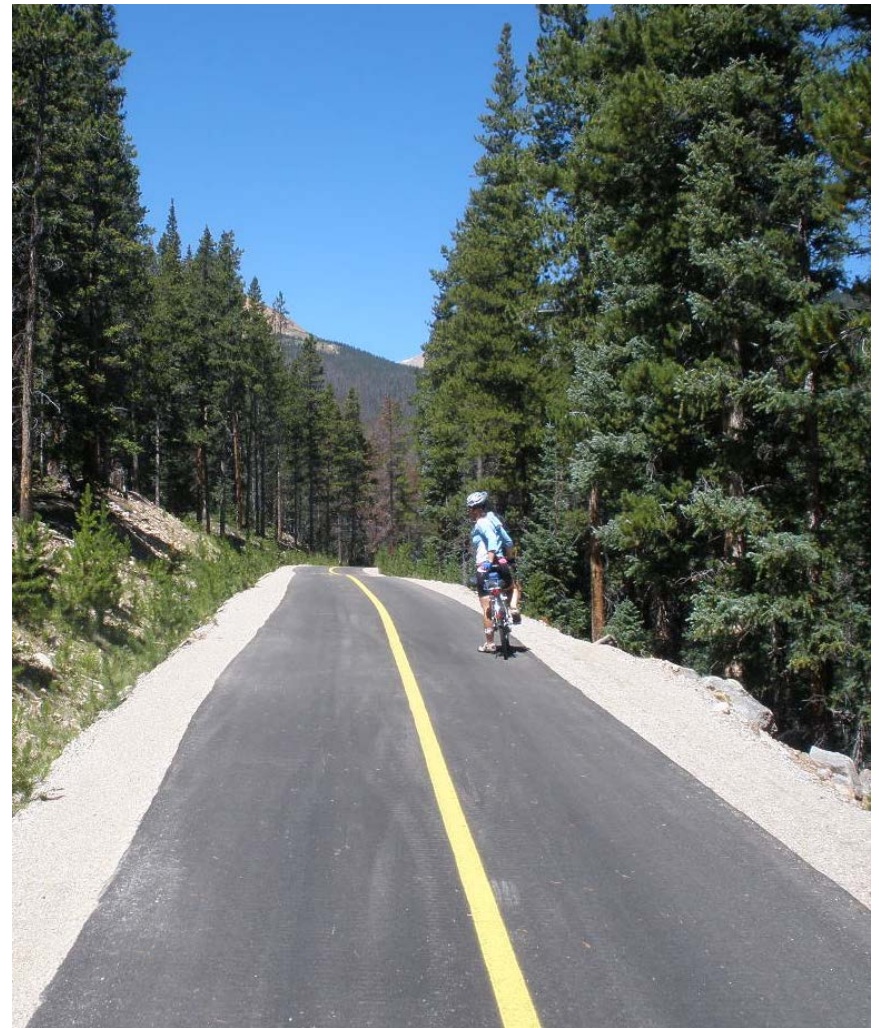
Urban vs. Rural

Arterial/Highway vs. Local/Collector/Path

WSDOT EcoRegions
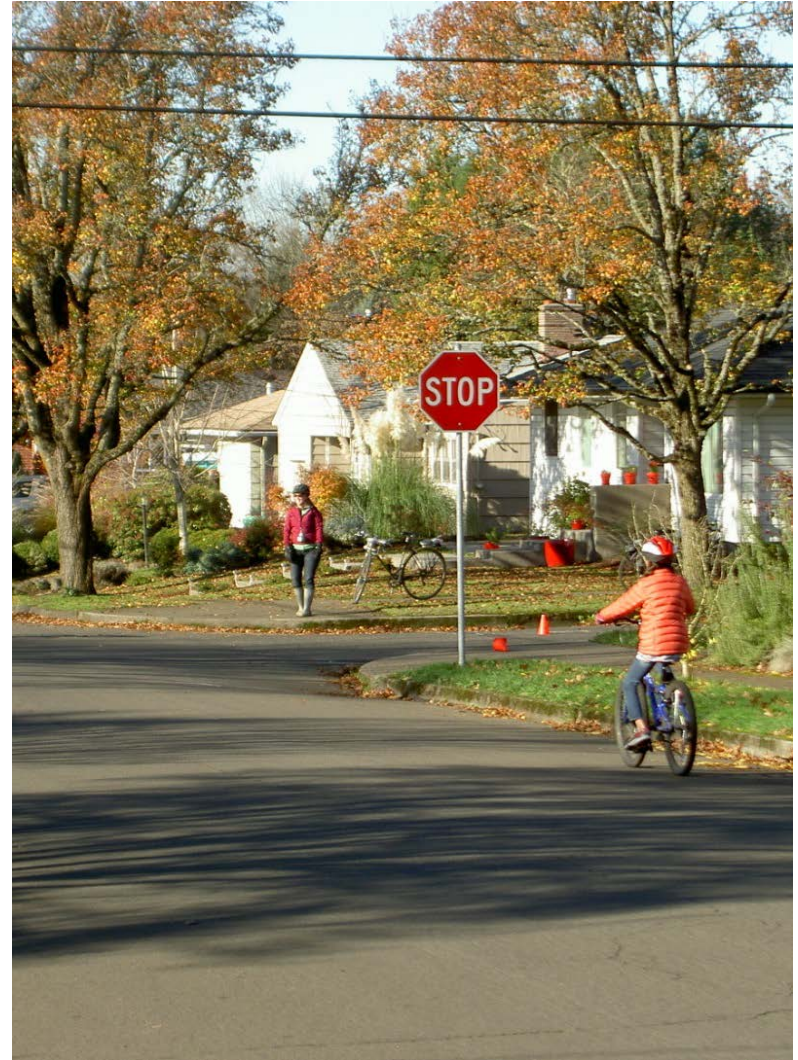
	Coast Range Region
	Cascades Region
	Puget Lowland Region
	Eastern Washington Region
	Urban Areas
•	Count Sites
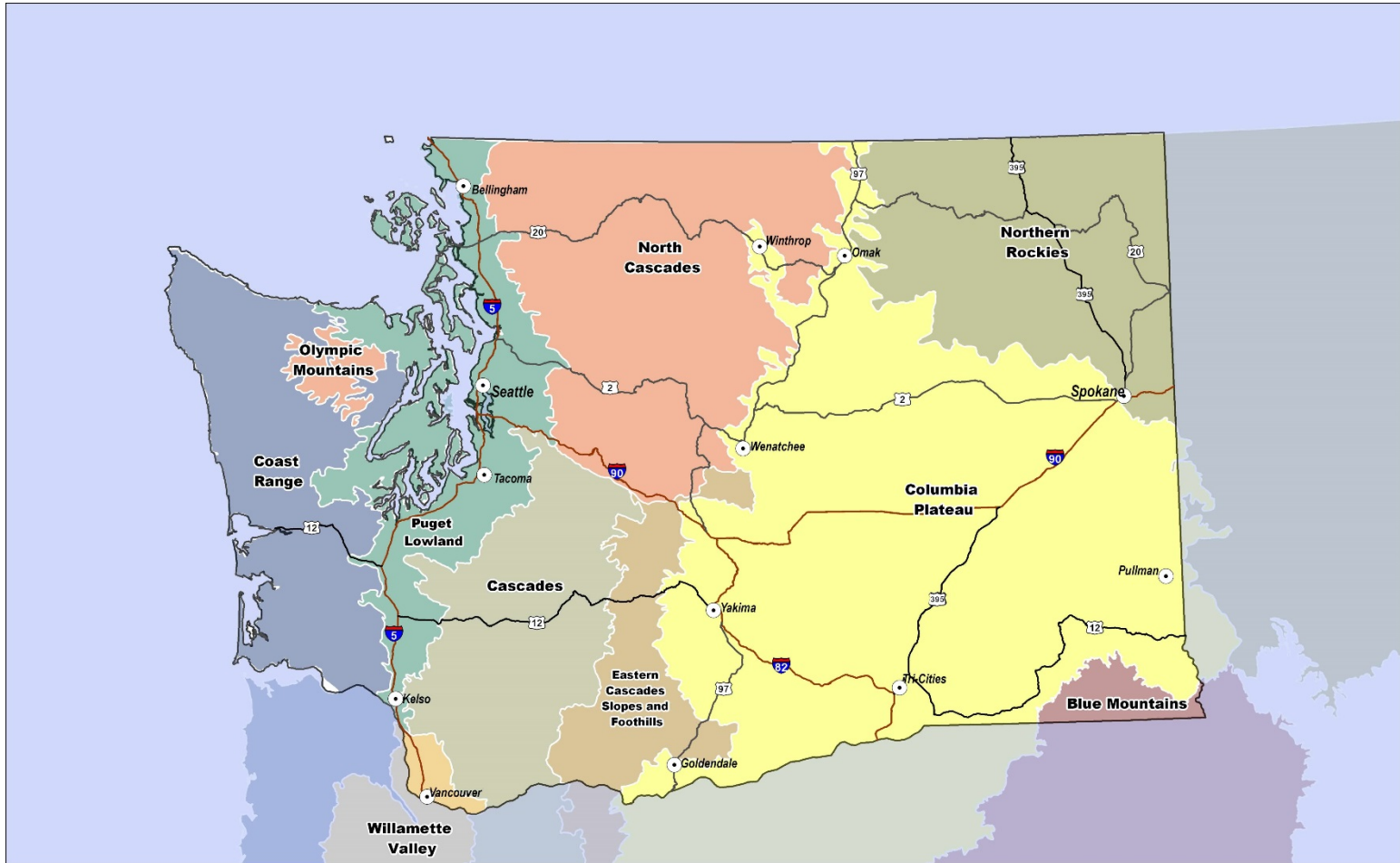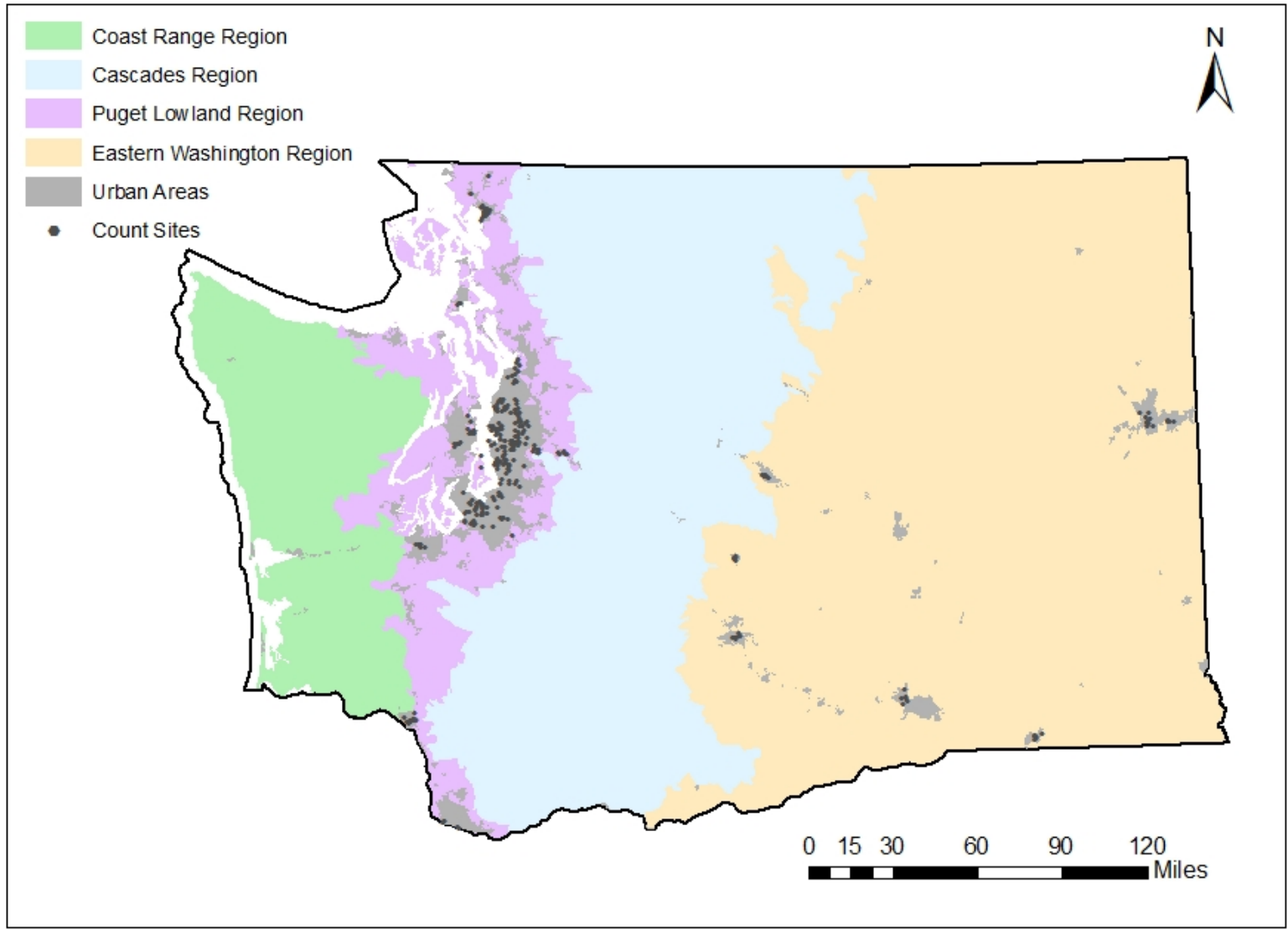
Count-based Method

- Groups

     4 Regions X 2 Urban/Rural X 2 Road Type=

          16 Groups

- Compute center lane miles for each

- Compute Average Annual Daily Bicycle and Pedestrians (AADBP) for each.

- Compute PMT or BMT

     = Miles X AADBP X 365 days/year

Traffic Patterns

- Seattle – one year of data
- Olympia – multiple sites with 7 days of data

Fremont Bridge, Seattle
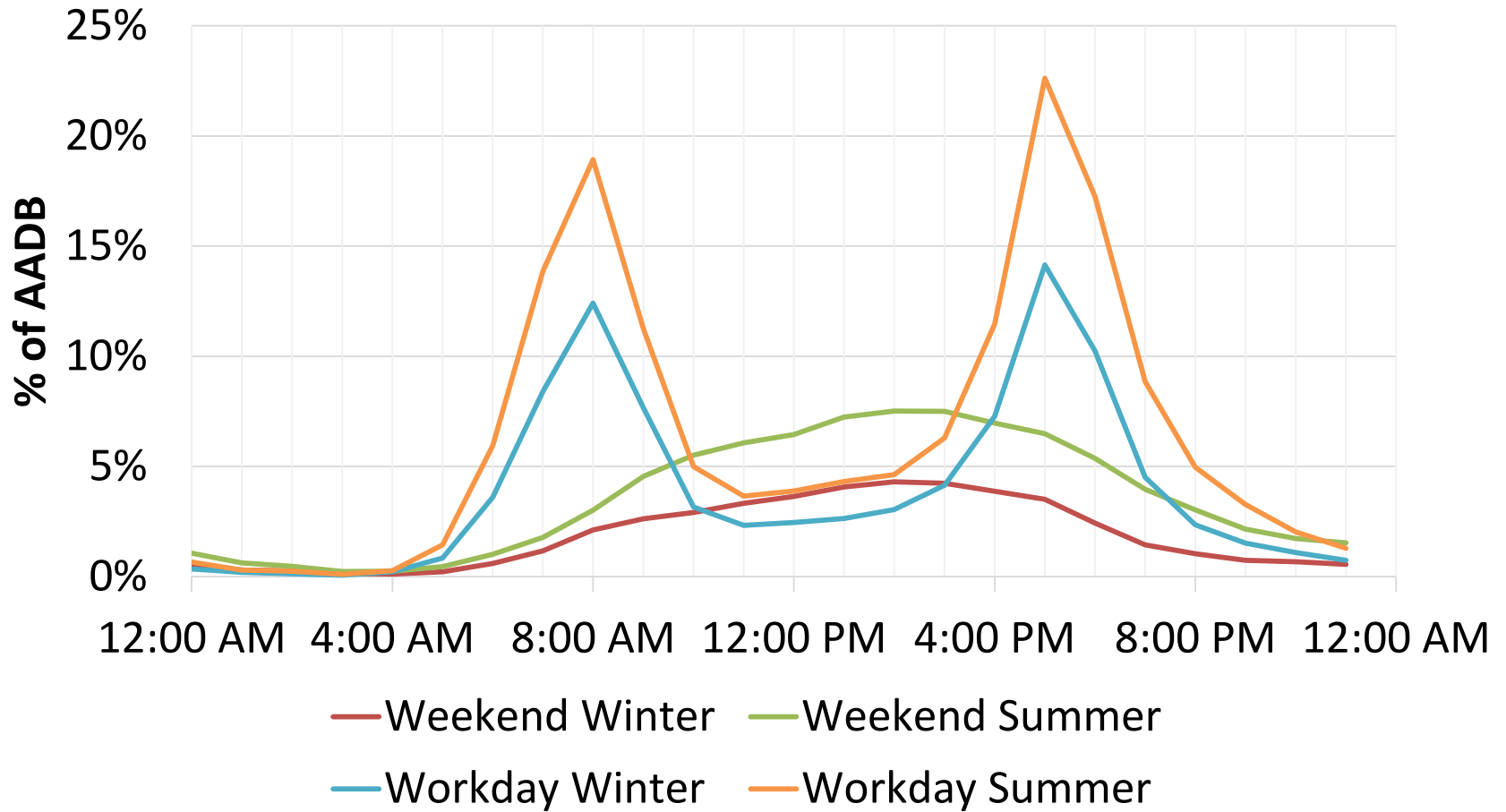
Annual Average Daily Bicyclists (AADB) = 2,461

Fremont Bridge, Seattle
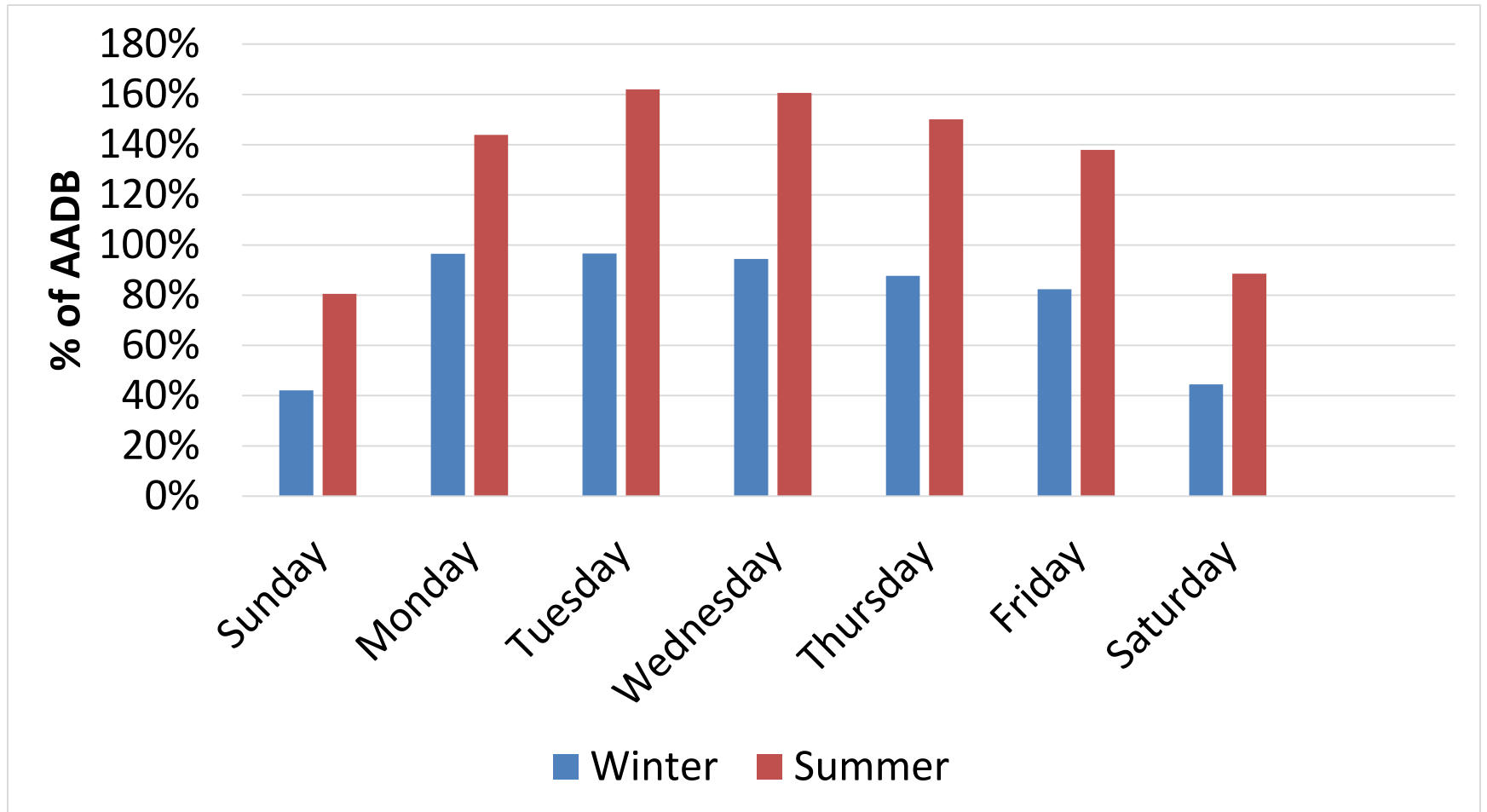
Fremont Bridge, Seattle
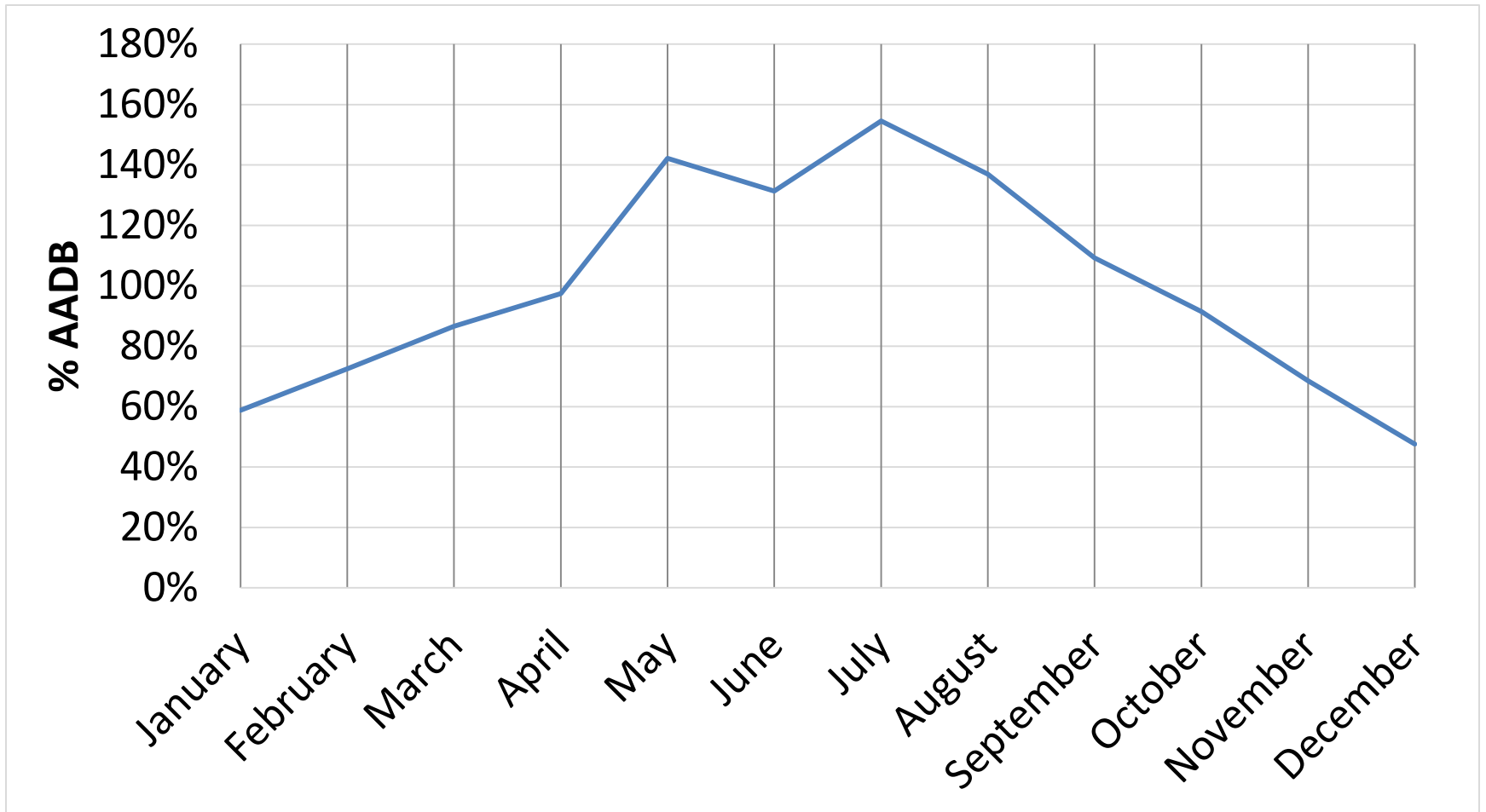
Annual Average Daily Bicyclists (AADB) = 2,461

Factoring Method

Adapted from Traffic Monitoring Guide

$AADB = C_{known} * M * D$

C_{known} = hourly count

M = Monthly Factor

D = Daily/Hourly Factor

Monthly Factor

December

$$M = \frac{AADB}{MADB} = \frac{2{,}000}{1{,}000} = 2$$

Daily counts in December are half of AADB.

where

MADB = Ave daily bike count in that month

Created Monthly Factors

Month	Monthly AADB	Factor
January	1,448	1.7
February	1,787	1.4
March	2,132	1.2
April	2,400	1.0
May	3,502	0.7
June	3,237	0.8
July	3,806	0.6
August	3,373	0.7
September	2,691	0.9
October	2,254	1.1
November	1,688	1.5
December	1,173	2.1

Created Daily/Hourly Factors

	7-8 AM Week-day	8-9 AM Week-day	10-11 AM Week-day	11-Noon Week-day	4-5 PM Week-day	5-6 PM Week-day	6-7 PM Week-day	Noon-1 PM Satur-day	1-2 PM Satur-day
January	9.0	6.1	26.5	32.3	11.0	5.5	8.1	28.3	21.0
February	8.8	6.0	28.4	33.4	11.2	5.4	7.8	17.1	16.3
March	9.9	7.1	29.4	39.3	13.2	6.3	8.6	13.9	12.5
April	8.2	6.2	25.7	31.4	10.0	5.3	6.7	26.9	33.1
May	8.7	6.7	29.9	41.0	12.1	5.6	7.5	21.4	17.5
June	9.3	7.1	27.8	34.8	11.4	5.7	7.3	16.2	14.4
July	10.3	7.5	25.7	33.9	12.0	6.2	7.9	19.2	18.0
August	9.8	6.8	24.6	33.4	11.7	5.7	7.1	22.1	19.8
September	8.7	5.8	23.7	31.6	10.8	4.9	6.2	27.6	24.5
October	14.5	15.2	17.4	17.0	14.4	15.3	22.0	25.1	22.8
November	8.1	5.8	24.0	31.0	9.4	5.5	8.4	17.0	19.9
December	8.6	5.6	24.2	33.6	10.1	5.3	8.3	24.7	25.1

```
Continuous Counts → Seasonal Adjustment Factors → AADB/AADP → Aggregate Demand Model = Aggregate Demand BMT/PMT

Manual Counts → AADB/AADP

AADB/AADP X Road Segment Length = Count-Based BMT/PMT
```

Aggregate Demand Model

- Uses the AADB and AADP estimations calculated from manual and automated count data. Each AADB and AADP estimation was then associated with the following variables:
  - Facility type: This variable has three categories.
    - Local and collector roads
    - Arterial roads and highways
    - Trail
  - Bridge: This is a dummy variable which indicates if the bicyclist or pedestrian is crossing a bridge.
  - Population density: Density of population in the census tract
  - Percent of the population aged 18 to 54
  - Percent of the population with a four year degree or more

Aggregate Demand (cont.)

- These models can then be used to calculate BMT and PMT at the statewide level using the following procedure:
    - Associate road and trail segments throughout the state with the corresponding census tract and American Community Survey (ACS) data.
    - Apply the explanatory variables to each segment to estimate AADB and AADP for the segment.
    - Multiply AADB and AADP by the length of the segment.
    - Sum all of the segments throughout the state.
    - Multiply by 365 to get estimates for annual PMT and BMT.

National Household Survey Method

- "Back of the envelope" method
- Uses research from Pucher et al.
- NHTS and Census Data
- Puget Sound Regional Travel Survey

# RESULTS

Available Data in 16 Groups

Sampling Groups			Number of Continuous Stations Available	Stations Available in State's Count Program
Region	Level of urbanism	Road/Path Type		
Coast Range	Rural	Arterial/Highway	0	0
	Rural	Local/Collector/Path	0	0
	Urban	Arterial/Highway	0	0
	Urban	Local/Collector/Path	0	0
Puget Lowland	Rural	Arterial/Highway	0	1
	Rural	Local/Collector/Path	0	0
	Urban	Arterial/Highway	1	157
	Urban	Local/Collector/Path	1	99
Cascades	Rural	Arterial/Highway	0	0
	Rural	Local/Collector/Path	0	0
	Urban	Arterial/Highway	0	0
	Urban	Local/Collector/Path	0	0
Eastern Washington	Rural	Arterial/Highway	0	0
	Rural	Local/Collector/Path	0	0
	Urban	Arterial/Highway	0	37
	Urban	Local/Collector/Path	0	6
			Total	304

Note: There are 13 count sites for which the location is ambiguous or unknown.

Count-based Estimates

- Using the available data, annual PMT and BMT were estimated for four of the sixteen groups.
- Bicycle and pedestrian traffic on trails was significantly higher, on average, than on local streets.
- Trail site count data was removed from the local street sampling groups.
- Estimates are biased toward over estimation, since count sites were deliberately chosen at locations where bicycle and pedestrian activity tend to be high.
- This bias can be corrected in the future by randomly sampling count locations.

	Puget	Eastern
BMT	1155 ± 272	335 ± 136
PMT	3522 ± 771	1363 ± 588

Estimates Using Count-Based Method (Millions of Miles)
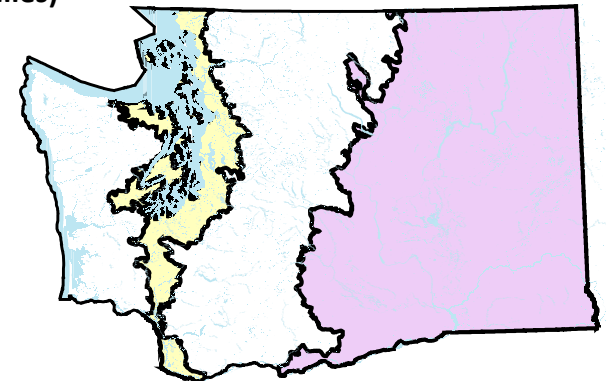
Aggregate Demand Estimates

The equation for the bicycle model is:

$$\log(AADB + 1) = 0.620 + (1.766 \times 10^{-5})x_1 + 0.010x_2 + 0.009x_3 + 0.212x_4 + 0.625x_5 + 0.635x_6$$

(5-2)

The equation for the pedestrian volume model is:

$$\log(AADP + 1) = 1.342 + (3.784 \times 10^{-5})x_1 + 0.012x_2 + 0.001x_3 + 0.095x_4 + 0.187x_5 + 0.117x_6$$

(5-3)

where

$x_1 = $ Population density (people/square mile)
$x_2 = $ Percent of the population between 18 and 54
$x_3 = $ Percent of the population with a four-year degree
$x_4 = $ Arterial (1 if count site is located on an arterial, 0 otherwise)
$x_5 = $ Bridge (1 if count site is located on a bridge, 0 otherwise
$x_6 = $ Trail (1 if count site is located on a trail, 0 otherwise)

Aggregate Model for Bicycle and Pedestrian Models

Independent Variables	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
Bicycle Model: log(AADB) is dependent variable					
(Constant)	.620	.119		5.215	.000
Population Density	1.766E-05	.000	.145	3.759	.000
% of Pop 18-54	.010	.002	.179	4.665	.000
College Degree	.009	.001	.255	7.977	.000
Arterial	.212	.044	.161	4.761	.000
Bridge	.625	.125	.159	4.978	.000
Trail	.635	.063	.343	10.023	.000
Pedestrian Model: log(AADP) is dependent variable					
(Constant)	1.342	.142		9.481	.000
Population Density	3.784E-05	.000	.251	5.959	.000
% of Pop 18-54	.012	.003	.191	4.546	.000
College Degree	.001	.001	.015	.399	.690
Arterial	.095	.053	.070	1.790	.074
Bridge	.187	.147	.047	1.272	.204
Trail	.117	.074	.063	1.585	.113

NHTS Estimates

- 415 households surveyed in Washington State
- 891 individuals in the 2009 NHTS
- 96 (11%) reported making at least one bike trip in the past week
- 645 individuals (72%) reported making at least one walking trip in the past week
- Only 2 and 9 individuals biked and walked to work in the past week, respectively
- Necessary to use nationwide data in order to produce an acceptable sample size of bicyclists and walkers.

Statewide Estimates Using National Survey Method (in Millions of Miles)

Year	PMT (95% CI)*	BMT (95% CI)*
2010	710 (680 to 740)	150 (140 to 170)
2013	730 (700 to 770)	160 (150 to 180)

* The confidence interval (CI) only accounts for error from the National Household Travel Survey as reported by Pucher et al. 2011 (Pucher, Buehler et al. 2011). Actual error is much higher.
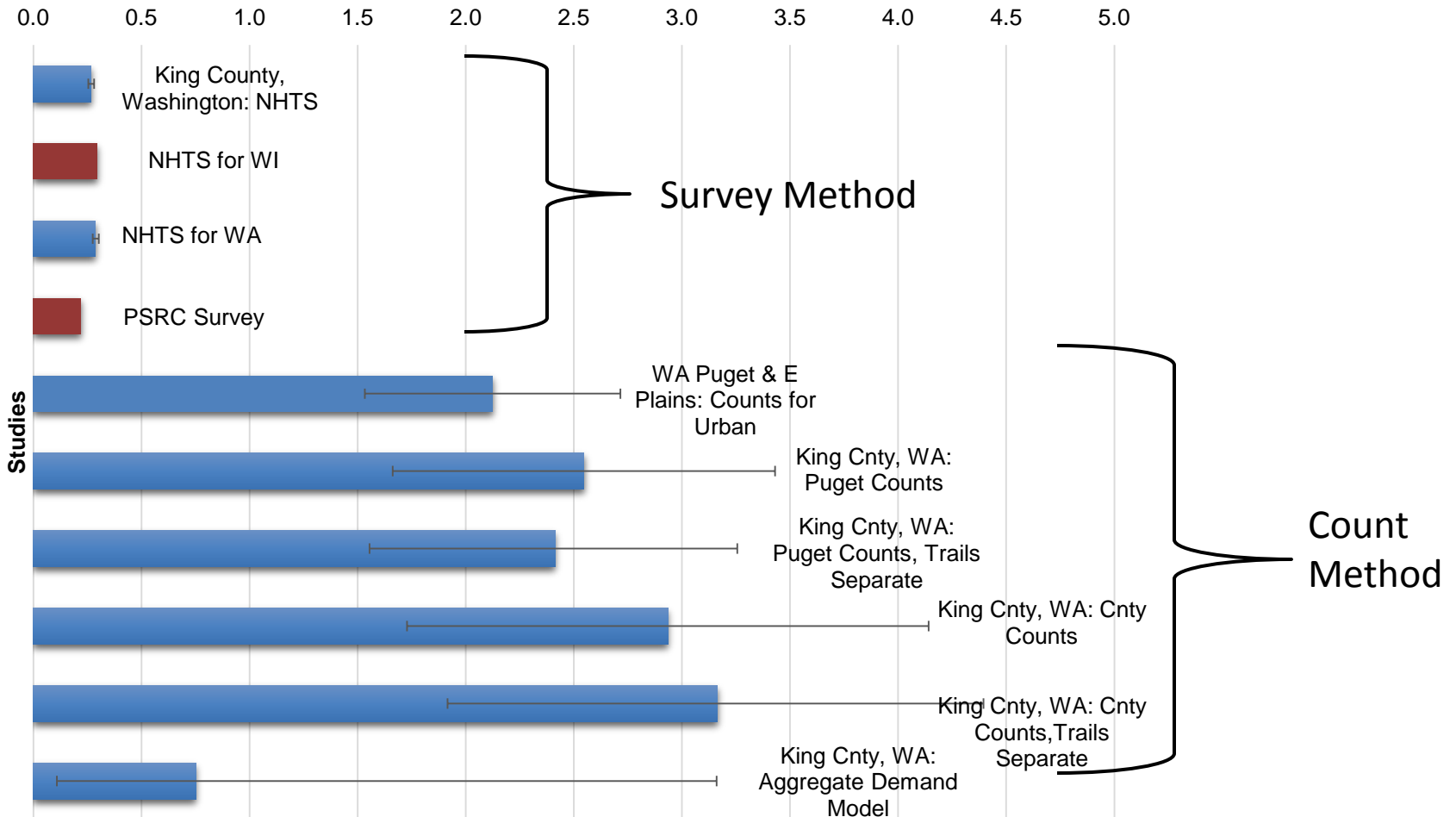
King County Comparison

Annual PMT and BMT for King County within the Puget Lowlands (Millions of Miles)

Method	Lower PMT	PMT	Upper PMT	Lower BMT	BMT	Upper BMT
National Survey Data	190	200	210	40	45	50
Count Based Method (All Puget Sites)	1,240	1,900	2,560	540	710	880
Count Based Method (All Puget Sites Trails and Local Separated)	1,160	1,800	2,430	370	510	650
Count Based Method (King County Sites Only)	1,290	2,190	3,090	770	1,050	1,330
Count Based Method (Trails and Local Separated)	1,430	2,360	3,280	460	690	930
Aggregate Demand Model	100	560	3,000	50	220	910

Comparison of Studies

PMT/Person/Day

CONCLUSIONS & RECOMMENDATIONS

Conclusions

Approach	Pros	Cons	Recommended Data Improvements
State-wide survey	Expanding existing dataset is easier than creating new dataset.	Data are not at the facility level.	Fund an oversampling of the next NHTS.
Count-based	Data are at the facility level.	- Data tend to be biased towards high count locations. - It is harder to sample pedestrian locations.	Expand count program to allow for a statewide representative sample.
Aggregate Demand Method	More accurate estimate of PMT and BMT.	Difficult to do at the state level.	Expand count program to allow for a statewide representative sample.

Recommendations for Counting Program

- In coming years:
  - Expand program to include rural areas and mountain regions
  - Install at least 1 permanent counter in each of the 16 groups
- In the coming decades:
  - At least 7 permanent counters per group.
  - Ideally count 7 days per location
  - At least 150 short duration count sites per group

Discussion & Questions

Krista Nordback, P.E., Ph.D.

nordback@pdx.edu

503-725-2897

Mike Sellinger

mikesellinger@altaplanning.com

Taylor Phillips

tphill2@pdx.edu

Transportation Research and Education Consortium

Portland State UNIVERSITY

TREC

Why measure walking & biking?

If we don't count it, it doesn't count.

Conclusions

- Existing count data are not sufficient for BMT/PMT estimation

- More data needed

- Random sampling needed to get better representation

- Combining with GPS data potential

- For bikes – count based approach OK

- For peds – aggregate approach more appropriate

Adventure Cycling

Adventure Cycling Route Mileage Estimates

Adventure Cycling		Map Sales by Year				
Route Name	**Section Number**	**2011**	**2012**	**2013**	**Total Route Mileage**	**Miles Biked 2013 (Map Sales * Route Mileage)**
Pacific Coast	1	728	819	694	317	220,000
Northern Tier	1	389	387	364	419	152,520
Sierra Cascades	1 &2	542	561	449	897	402,750
Washington Parks	1 &2	367	369	438	1,046	458,150
Lewis and Clark Trail	7	283	263	252	324	81,650
Totals		2,309	2,399	2,197	3003	**6,597,590**

Ride with GPS & Strava Data

Strava Global Heat Map
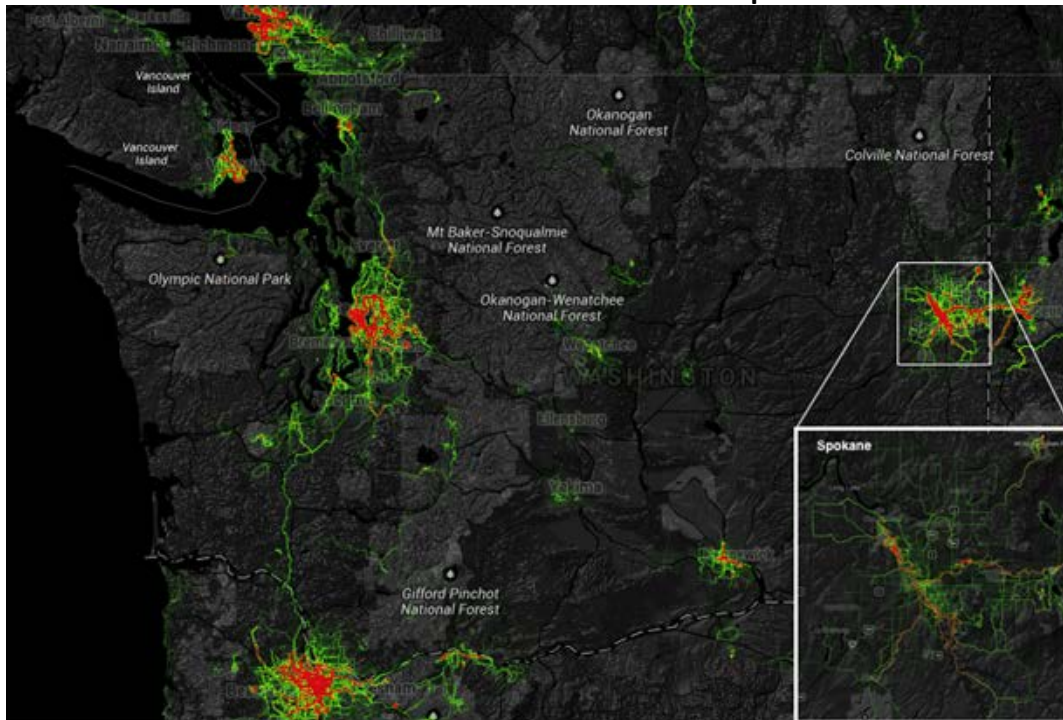
Ride with GPS Data

Number of GPS Uploaded Trips Across Years	
2005	48
2006	54
2007	58
2008	438
2009	1,001
2010	2,878
2011	6,285
2012	12,885
2013	21,888
2014	7,451
Total	**52,986**

Organized Group Rides

Name	Start Location	Distances	Number of riders	Miles Ridden
Seattle to Portland	Seattle	203	**10,000**	**2,030,000**
Chilly Hilly	Bainbridge Island	34	**3,005**	**102,170**
Flying Wheels Summer Century*	Redmond	40	1,570	62,800
		100	1,570	157,000
Totals			**3,139**	**219,800**
Bike MS*	Mt. Vernon	Day 1	1,800	
		22	34	737
		59	34	1,977
		78	34	2,613
		97	34	3,250
		Day 2	1,000	
		50	500	25,000
		75	500	37,500
Totals			**1,800**	**71,076**
RSVP	Seattle	187	**1,400**	**261,800**
RSVP 2	Seattle	187	**1,365**	**255,255**
Cycle the WAVE	Bellevue	12	134	1,608
		25	225	5,625
		42	300	12,600
		62	225	13,950
Totals			**884**	**33,783**
Kitsap Color Classic*	Kitsap	24	404	9,696
		57	404	23,028
Totals			**808**	**32,724**
Seattle Bike-n-Brews*	Seattle	25	391	9,775
		50	391	19,550
Totals			**782**	**29,325**
Obliteride	Seattle	25	224	5,600
		50	240	12,000
		100	159	15,900
		180	69	12,420
Totals			**692**	**45,920**
Grand Totals			**23,875**	**3,081,853**

*For rides where total riders were not given for each distance, ridership was distributed evenly between mileage options

Miles of Road/Trails

Region	Level of Urbanism	Road/Path Type	Total Miles
Coast Range	Urban	Arterial	409
		Collector	739
		Trail	6
	Rural	Arterial	128
		Collector	13,062
		Trail	69
Puget Lowlands	Urban	Arterial	4,042
		Collector	20,730
		Trail	344
	Rural	Arterial	183
		Collector	15,380
		Trail	163
Eastern Washington	Urban	Arterial	2,574
		Collector	7,140
		Trail	108
	Rural	Arterial	1,448
		Collector	54,407
		Trail	376
Cascades	Urban	Arterial	219
		Collector	352
		Trail	4
	Rural	Arterial	576
		Collector	33,526
		Trail	124
Total Centerline Miles in Washington State			**156,109**

Safe Routes to School
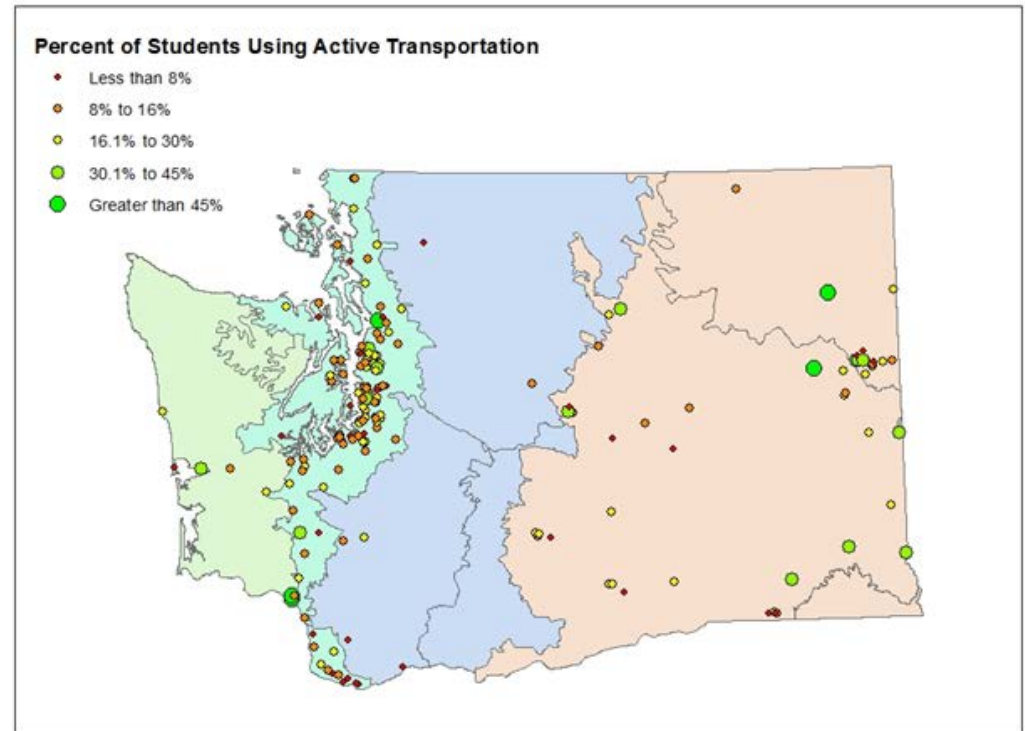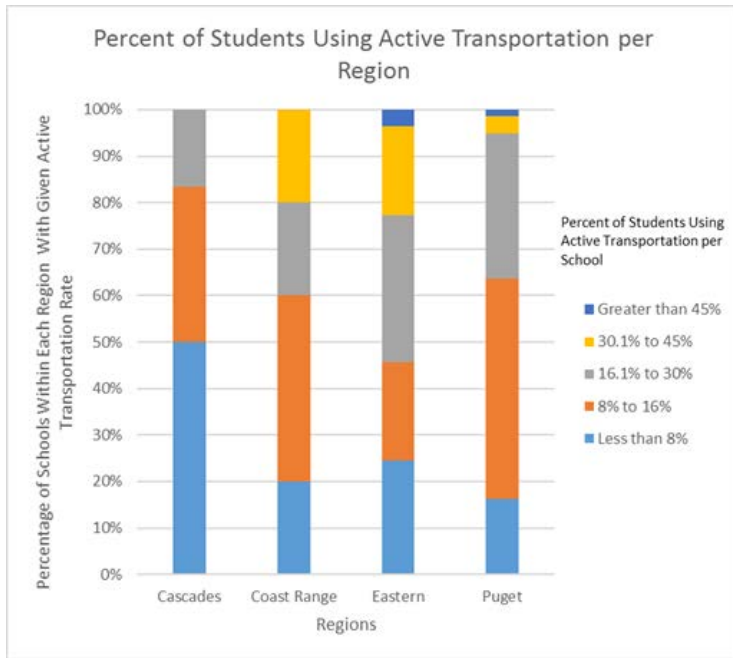
Count Data

- State's Count Program
- Olympia bike counts
- Seattle bike counts

Olympia

- TimeMark tube co
- 7 day counts
- Three times per year (March, June, October)

Year	Number of Locations
2008	9
2009	17
2010	17
2011	17
2012	19

Seattle

- Manual Counts
- 50 locations
- 4 times per year
  - 10:00 AM to noon Weekdays
  - 5:00 PM to 7:00 PM Weekdays
  - Noon to 2:00 PM Saturdays

- State's only permanent counter: Fremont Bridge
- New permanent counter on the Spokane St. Bridge

Seattle
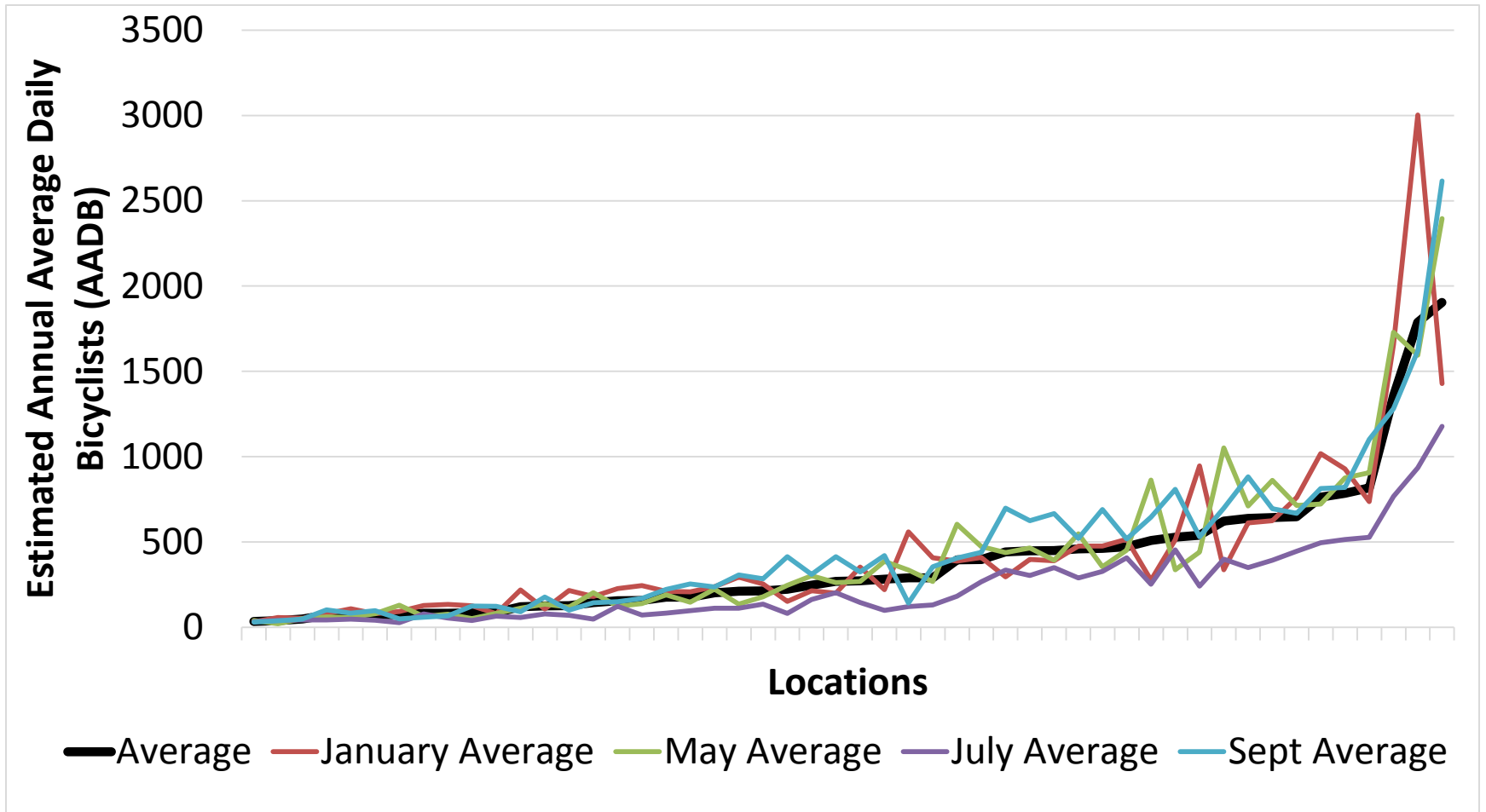
Olympia
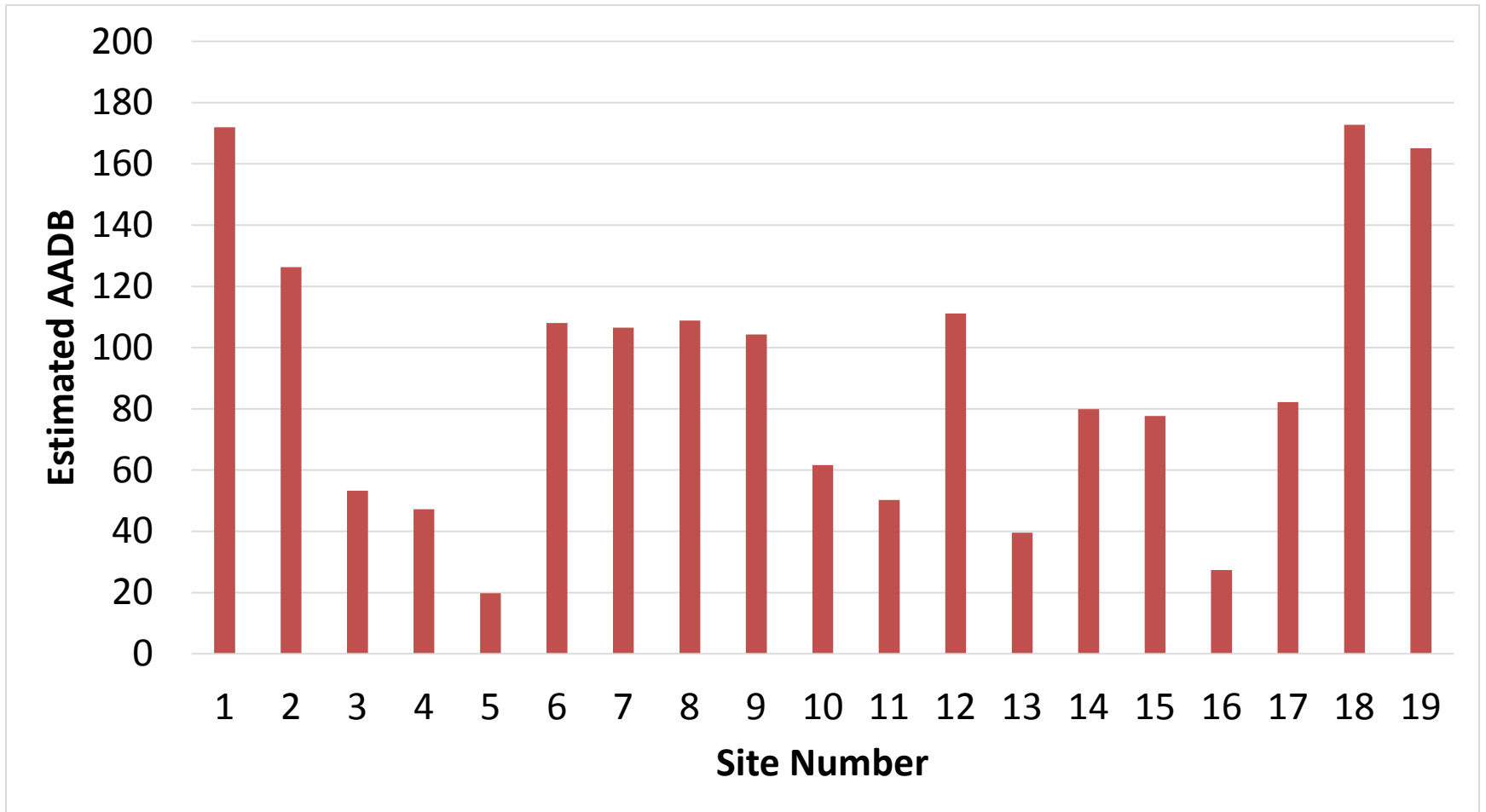
Olympia
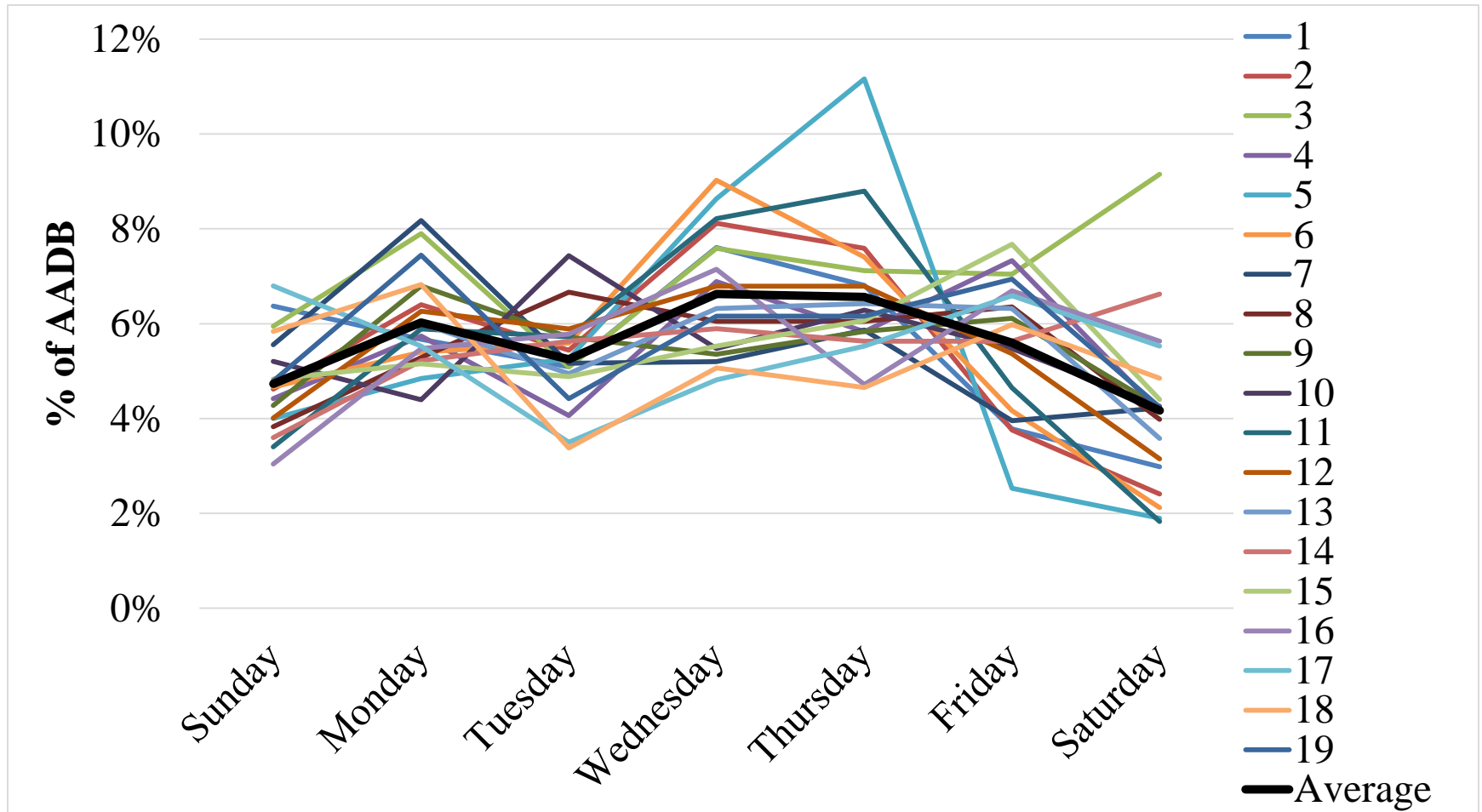
SUBURBAN CLASSIFICATION

Literature

- U.S. Dept of Agriculture – Rural-Urban Commuting Area Codes

- Ramsey & Bell (2014) – Smart Location Database

- Guiliano & Small (1991) – Subcenters

Washington State Densities

Not enough population density to warrant suburban vs urban distinction
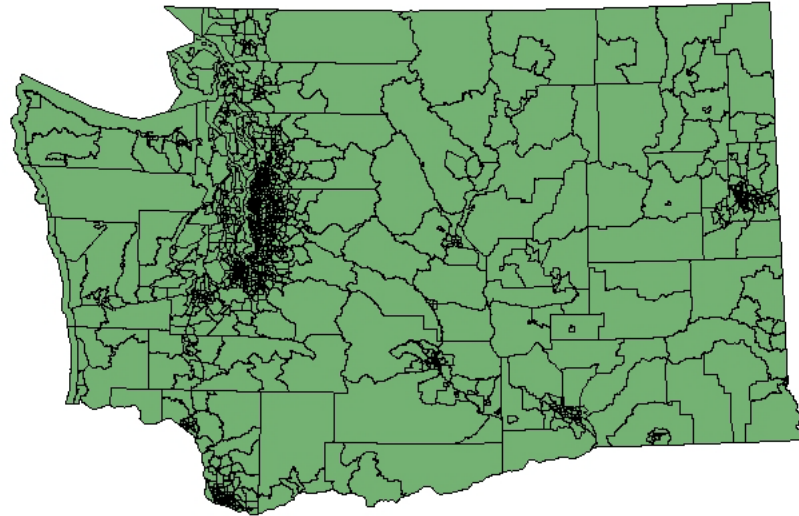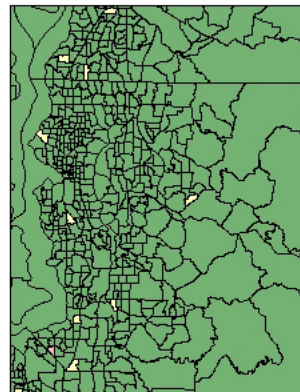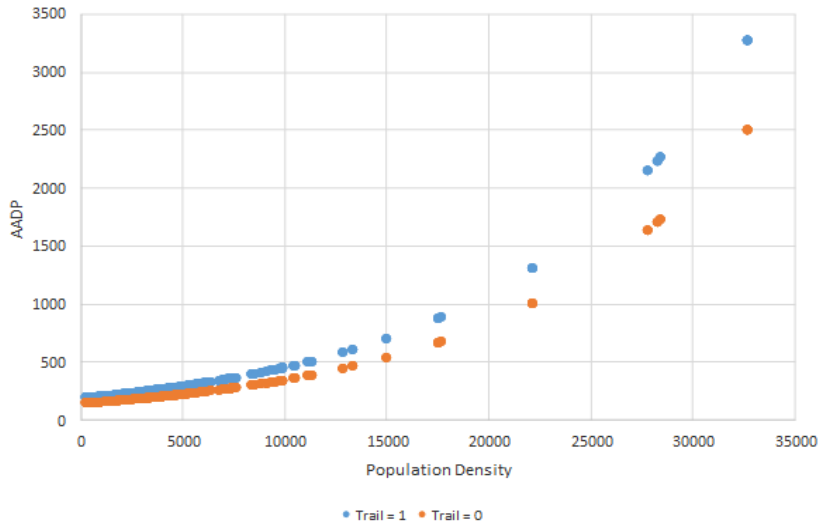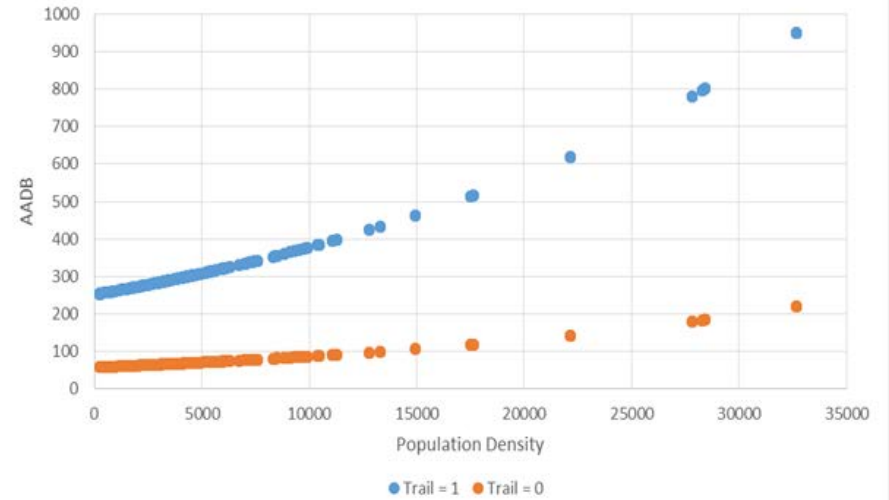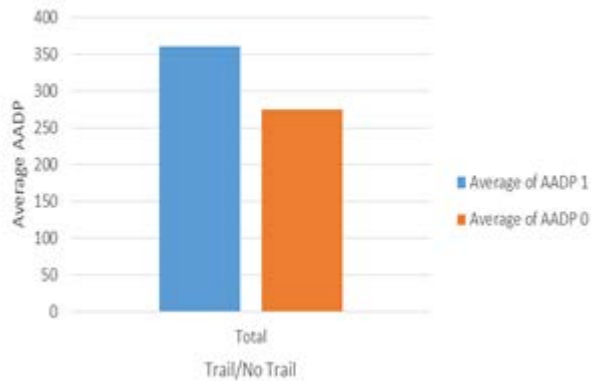
Trails
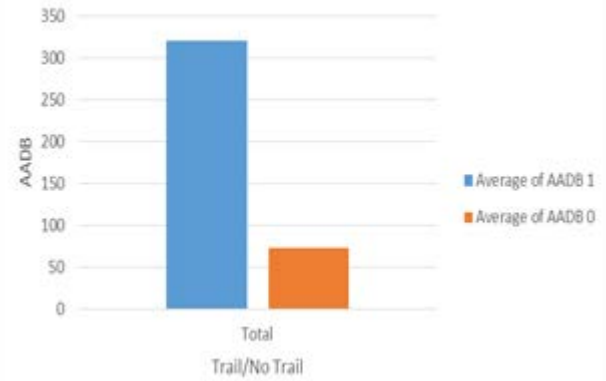
Past work

- Phase 1 – Recommendations to Improve State's Count Program
  - Identify Data Sources
  - Identify Methods
  - Recommend Changes
- Phase 2 – Methods for Estimating Bicycling and Walking
  - Prepare existing count data
  - Outline a method to use count data to compute BMT/PMT