UT18.602

Utilizing archived traffic signal performance measures for pedestrian planning & analysis

Dr. Patrick Singleton
Ferdousy Runa
Prasanna Humagain

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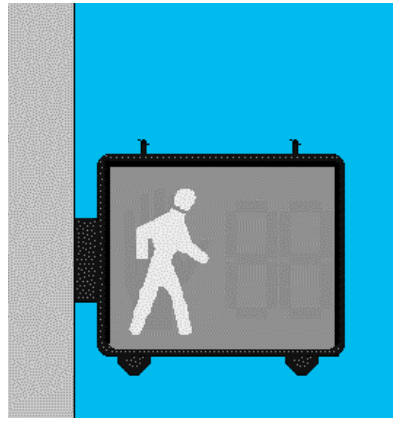
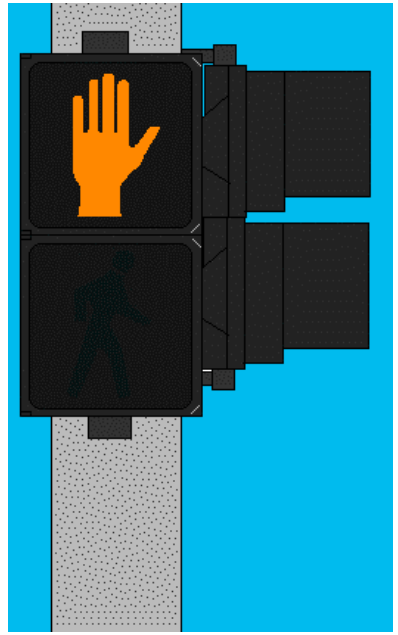
UDOT Keeping Utah Moving

UtahStateUniversity
CIVIL AND ENVIRONMENTAL ENGINEERING

Outline

- Project summary
- Patterns of pedestrian activity at traffic signals in Utah
- Methods to estimate pedestrian volumes from signal data
  - Video data collection
  - Counting pedestrians
  - Regression modeling
- Visualize pedestrian signal activity
- Recommend & implement





GIFs: http://www.galleryoflights.org/mb/gallery/thumbnails.php?album=408

Acknowledgements

- *Funding*: Utah Department of Transportation, Research Project 18.602
- *Technical Advisory Committee*: Heidi Goedhart, Kevin Nichol, Ryan Bailey, Dan Bergenthal, Travis Evans, Jamie Mackey, Angelo Papastamos, Matt Seipold, Mark Taylor, Stephanie Tomlin.
- *Students* (data collection): Skyler Allred, Colby Bench, Allie Boyer, Sadie Boyer, Kevin Brown, Maren Chadwick, Jordan Duncan, Emily Fica, Matthew Harris, Tyler Kendall, Jacob Leatham, Riley Manwaring, Luke Martineau, Niranjan Poudel, Nichole Rogers, Michael Ruiz-Leon.

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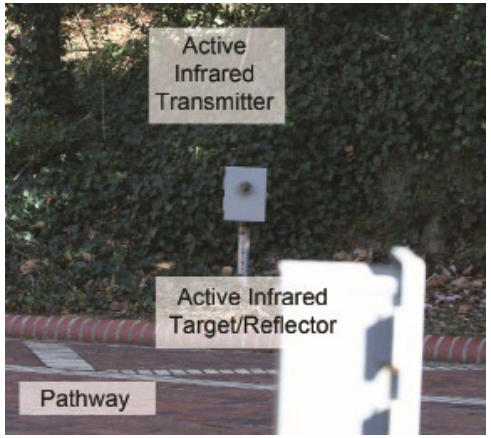
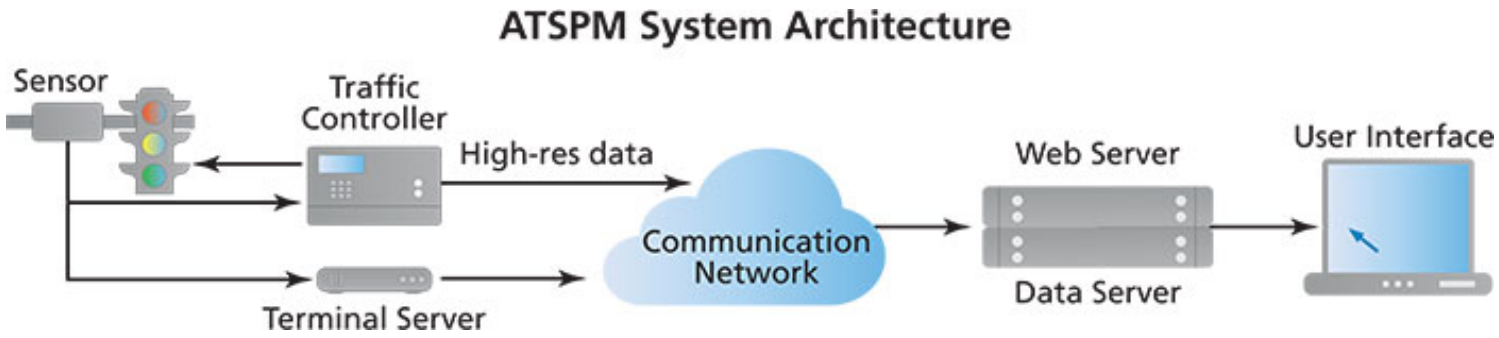
Motivation & opportunity

- Unmet need for pedestrian volumes
  - Intersection operations — Multimodal transportation planning
  - Traffic safety analysis — Health impact assessment
  - Existing methods: expensive, time-consuming
- High-resolution traffic signal controller data
  - Automated Traffic Signal Performance Measures (ATSPM)





Images: (right, top) https://www.fhwa.dot.gov/policyinformation/tmguide/, (right, bottom) https://www.cascade.org/blog/2014/11/2014-statewide-bikeped-counts (bottom) https://ops.fhwa.dot.gov/

Project overview

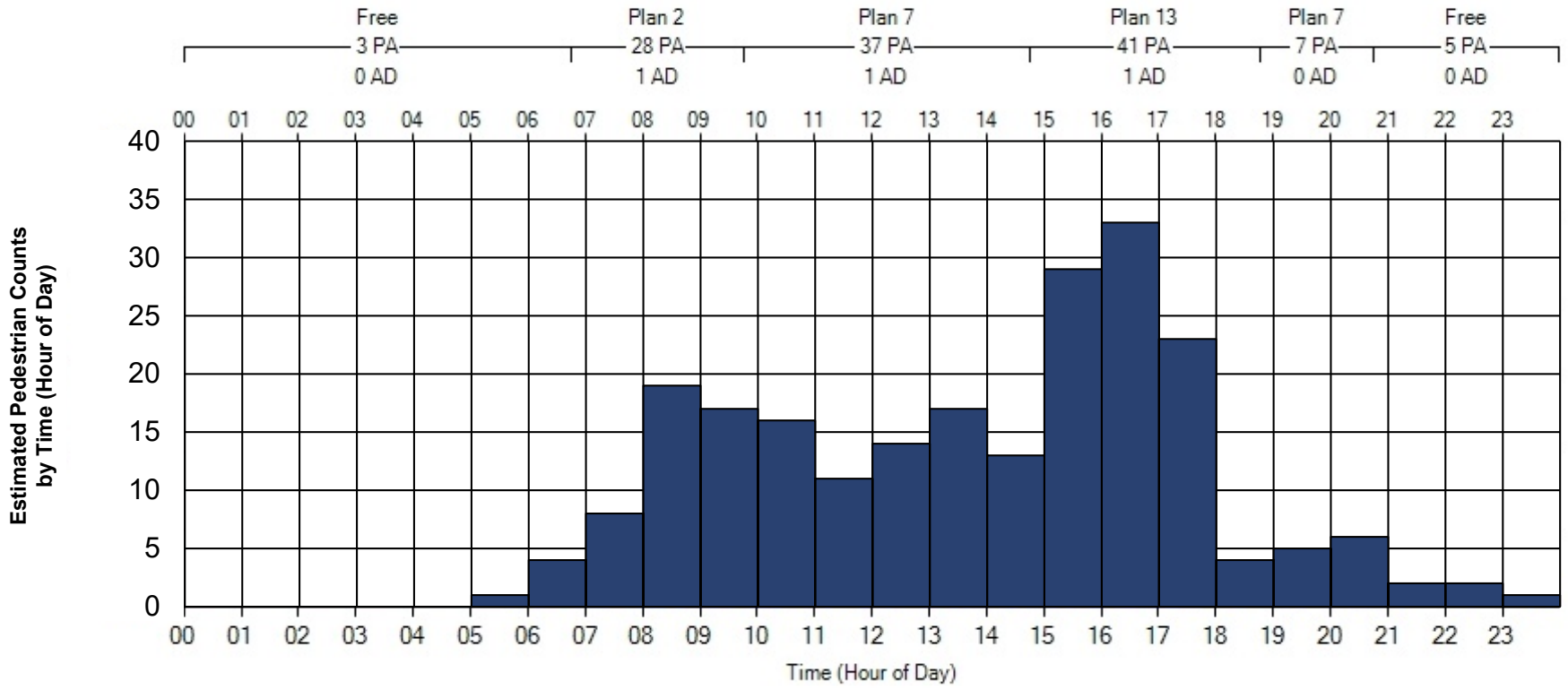
ATSPM
Automated Traffic Signal Performance Measures

Estimated Pedestrian Counts

400 North @ 600 East (Logan) - SIG#5314
Wednesday, November 29, 2017 12:00 AM - Wednesday, November 29, 2017 11:59 PM

Phase 4

Ped Actuations(PA) = 121; Min Delay = 00:00; Max Delay = 01:21; Average Delay(AD) = 00:30



Project objectives

- Explore the use of **continuous pedestrian actuation data** from the Automated Traffic Signal Performance Measures (ATSPM) system to develop **estimates of pedestrian activity**.

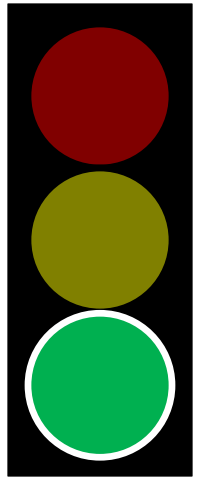
1. Identify **patterns** of pedestrian activity at traffic signals.
2. Develop methods to **estimate pedestrian volumes** from signal data.
3. Create a prototype to **visualize** pedestrian signal activity.

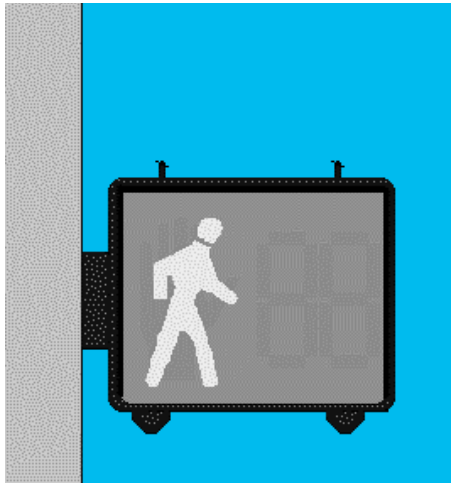
Project scope & tasks

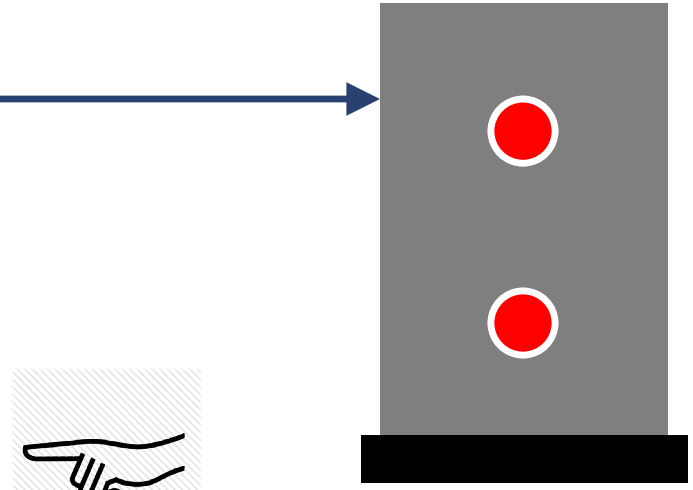
1. Assemble pedestrian data from traffic signals throughout Utah.
2. Analyze assembled data and identify traffic signal typologies based on pedestrian activity patterns and traffic signal settings.
3. Collect multi-day data on observed pedestrian counts at a sample of intersections using UDOT's overhead video cameras.
4. Compare counts to actuations, and use regression models to develop factoring methods that estimate pedestrian intersection crossing volumes.
5. Create a prototype online tool and graphical interface that visualizes estimated levels of pedestrian activity.

Pedestrian-related event codes

- Active Phase/Pedestrian Events
  - 0 Phase On
  - 21 Pedestrian Begin Walk
  - 22 Pedestrian Begin Clearance
  - 23 Pedestrian Begin Solid Don't Walk
- Detector Events
  - 90 PedDetector On
  - 89 PedDetector Off
- Phase Control Events
  - 45 Pedestrian Call Registered





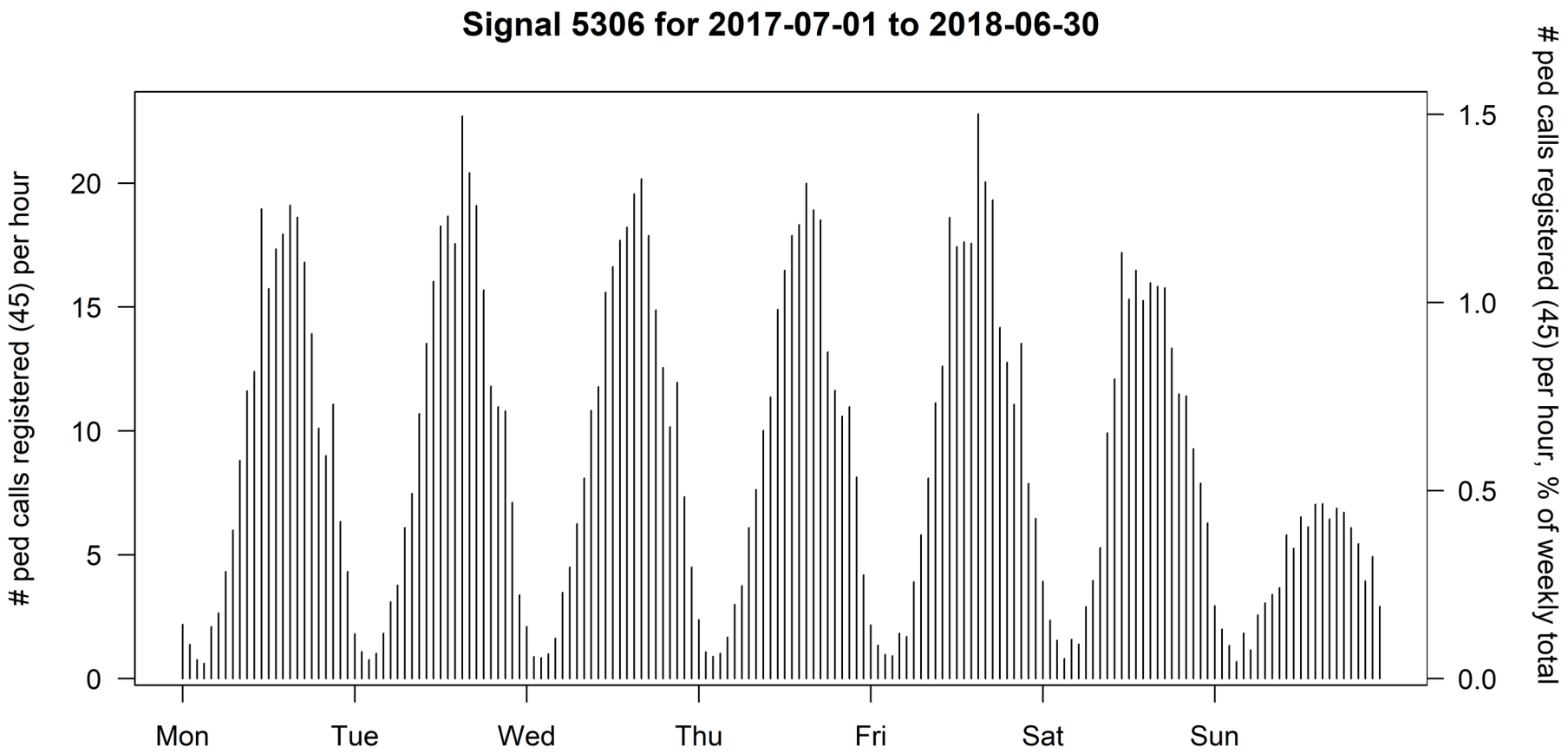


① Patterns: Pedestrian activity metrics

- Calculated "pedestrian activity metrics" (PAMs) for **1,522** signalized intersections, over **one year** (July 2017 – June 2018), averaged for all **168 hours** in a week

PAM	Equation	Definition
1	$\#90_t$	# pedestrian detections
2	$\#45_t$	# pedestrian calls registered
3	$\#90_t \div \#0_t$	# pedestrian detections per phase
4	$\#45_t \div \#0_t$	# pedestrian calls registered per phase
5	$100\% \times \#90_t \div \sum_t \#90_t$	# pedestrian detections (% weekly total)
6	$100\% \times \#45_t \div \sum_t \#45_t$	# pedestrian calls detected (% weekly total)

① Patterns: Pedestrian activity metrics



① Patterns: Time series clustering

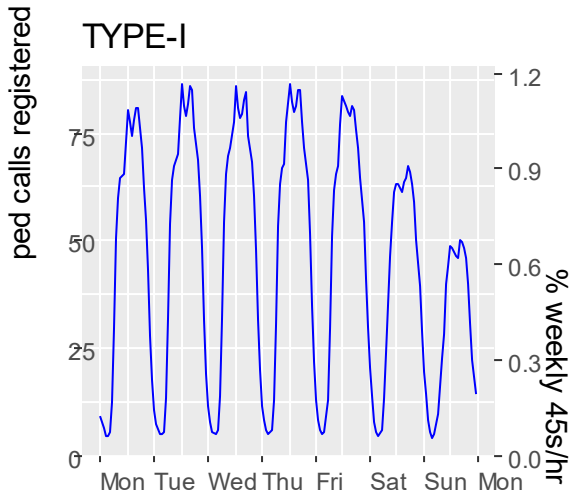
Analysis methods

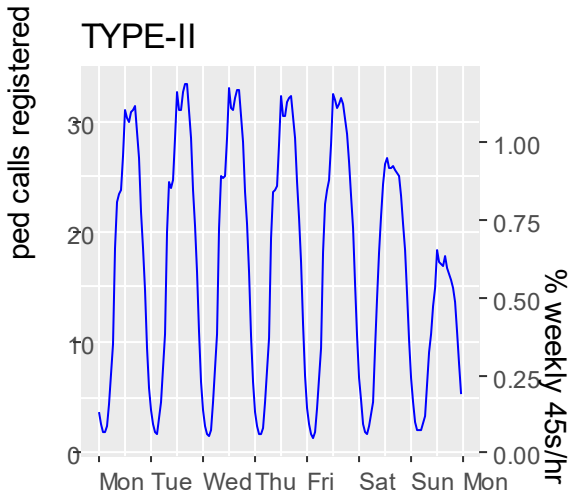
- Time series cluster analysis
  - 3 clusters
- PAM 2
  - Euclidian distance
  - K-means algorithm
- PAM 6
  - Temporal correlation
  - Hierarchical algorithm

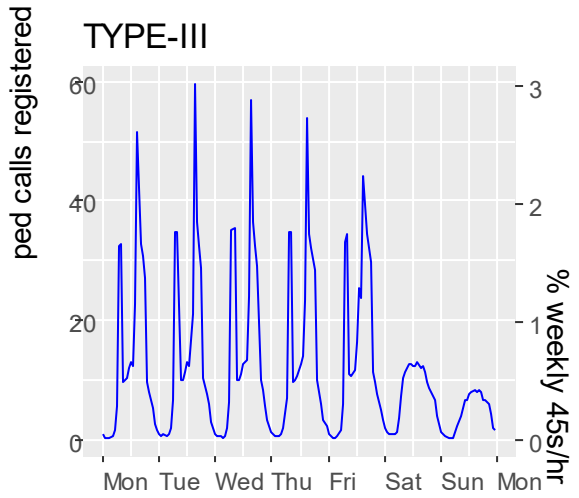
Results: Typologies

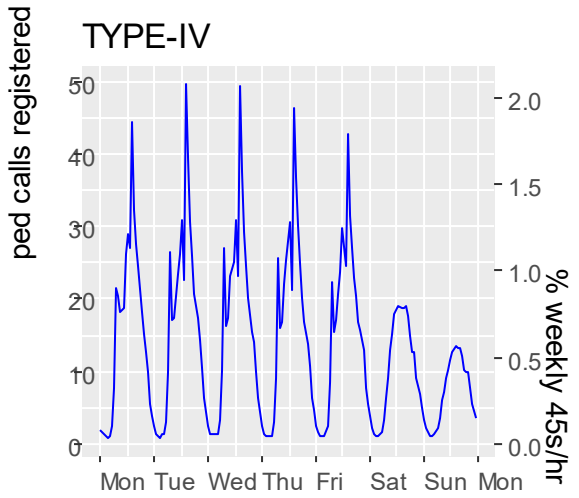
#	PAM 2	PAM 6	N
1	High	Single peak	33
2	Medium	Single peak	164
3	Medium	Double peak (a)	12
4	Medium	Double peak (b)	12
5	Low	Single peak	864
6	Low	Double peak (a)	252
7	Low	Double peak (b)	185

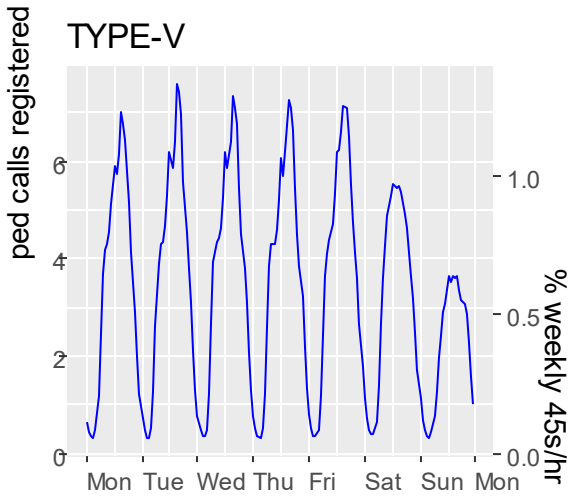
① Patterns: Typologies

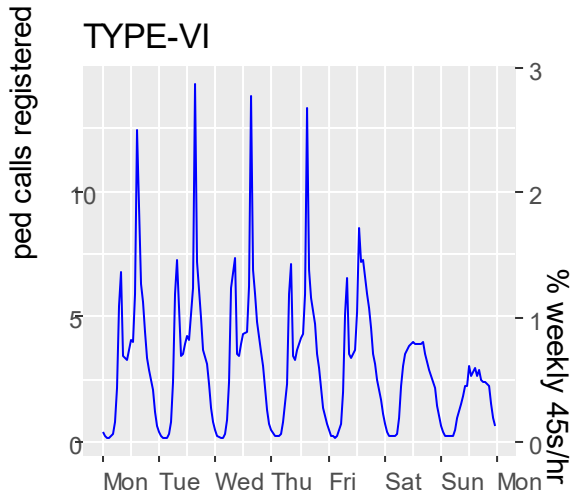


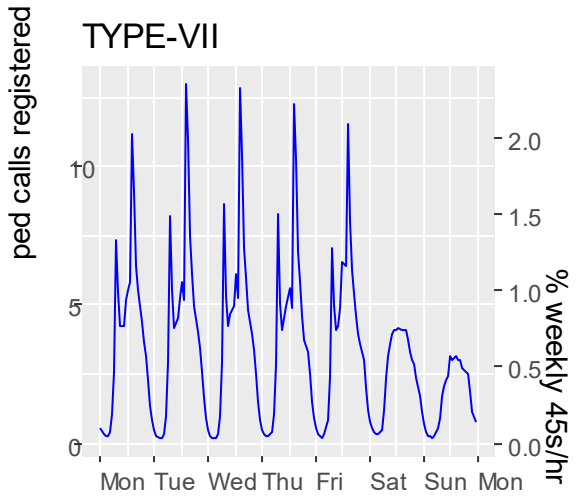




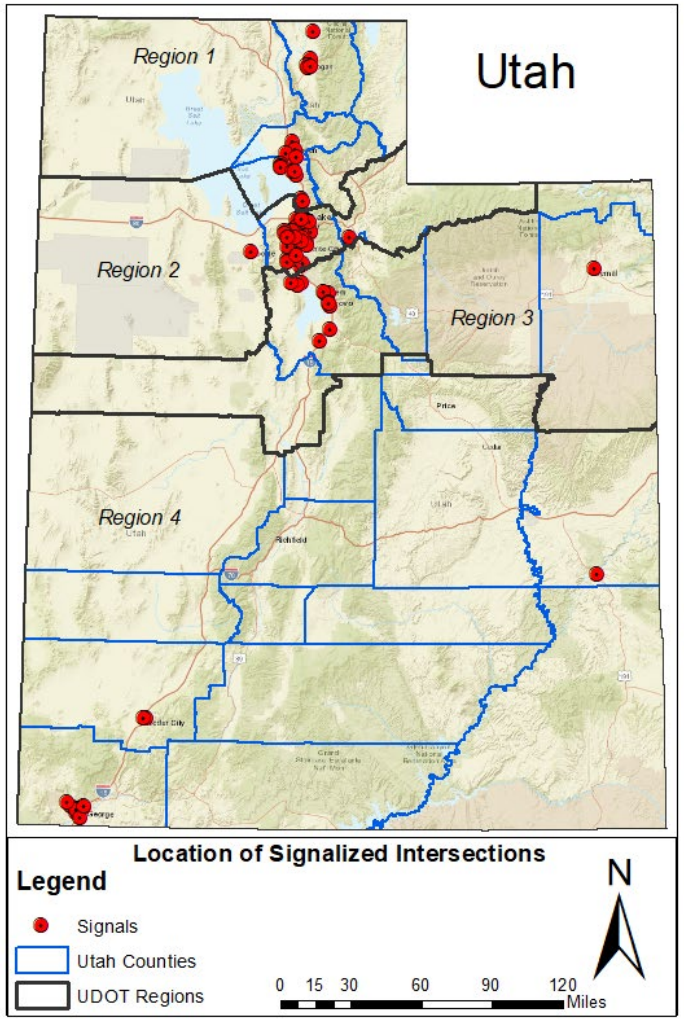


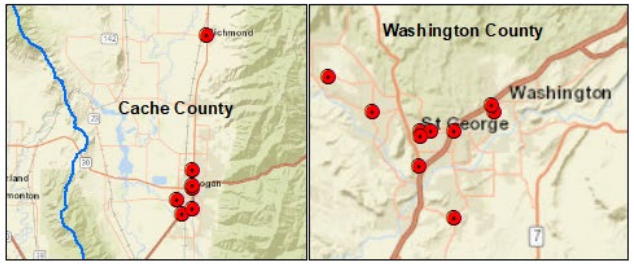


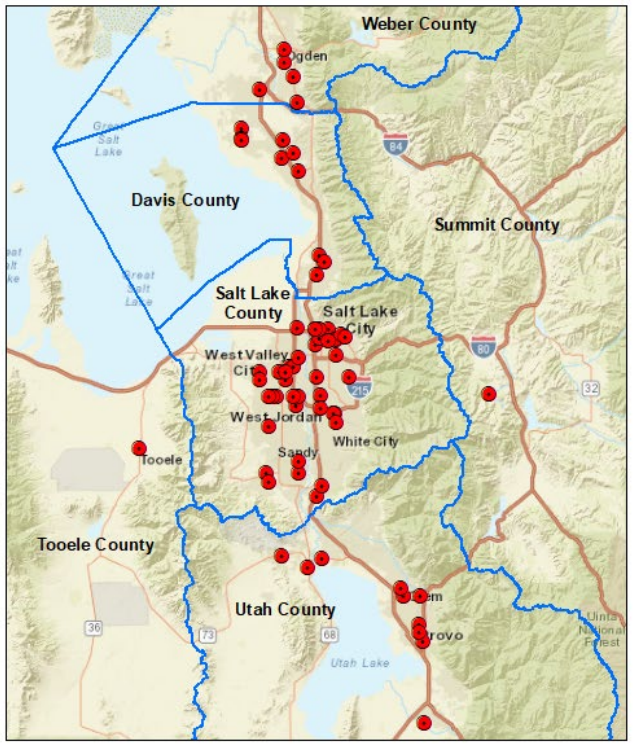




② Volumes: Study locations



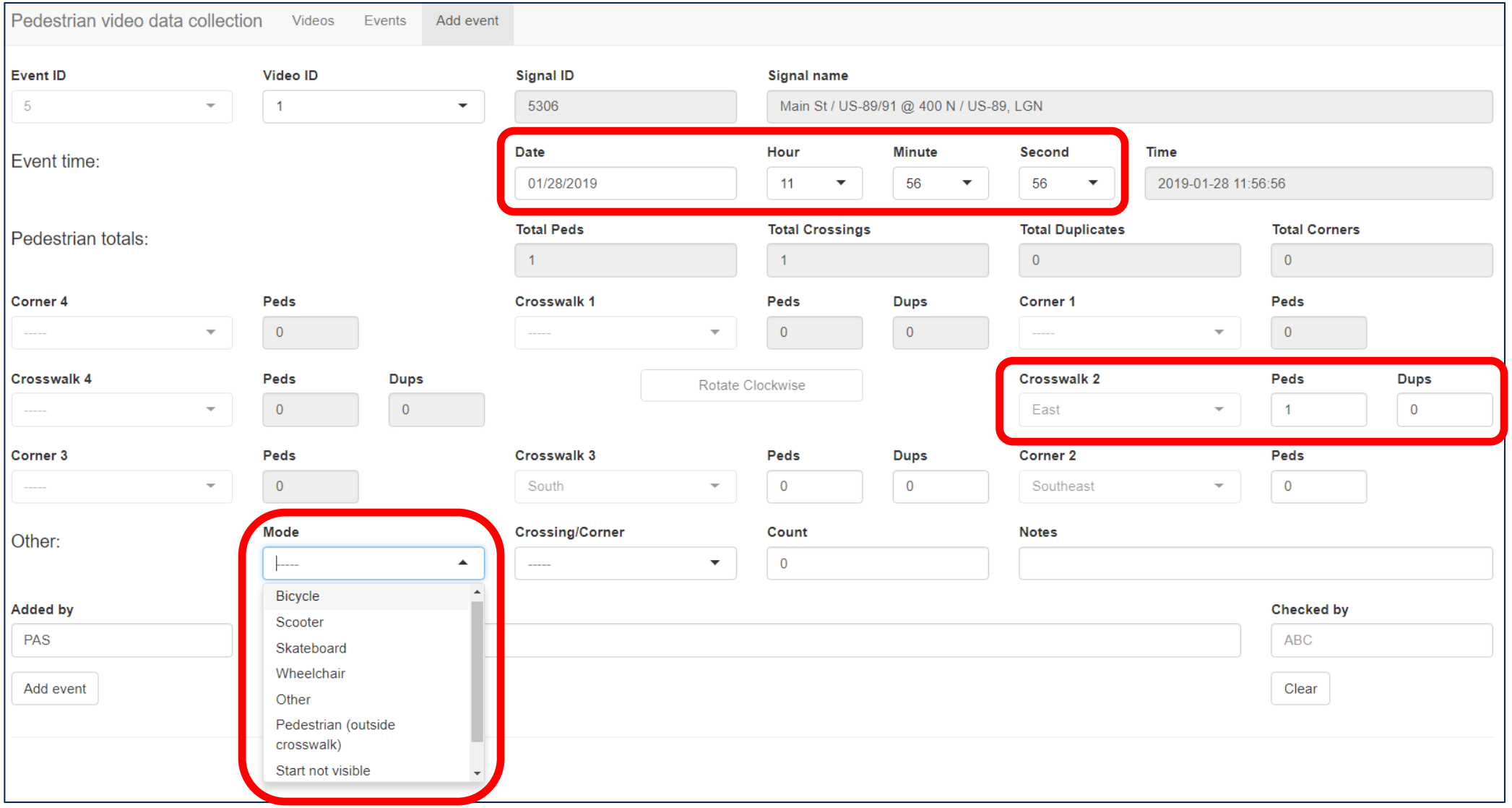




- 90 signalized intersections
  - Stratified random sampling by typology & UDOT region
- Typology
  - *Min*: 3 in Typologies I & III
  - *Max*: 41 in Typology V
- UDOT Region
  - *Min*: 12 in Region 3
  - *Max*: 43 in Region 2

② Volumes: Recording videos

② Volumes: Counting pedestrians



② Volumes: Video data collection

Videos

- UDOT traffic cameras
- 90 signalized intersections, 320 crosswalks
- 10,825 hours of videos, 24,085 crossing-hours of video
- All hours of the day, weekdays and weekends, and all seasons of the year (Jan – Dec, 2019)

Pedestrian events

- Counted around 175,000 pedestrians

Activity	Count
People walking	174,923
People bicycling	12,628
People using (e-)scooters	2,453
People skateboarding	897
People in wheelchairs	537
Other sidewalk users	221
Pedestrians crossing outside of crosswalk	1,151
Pedestrians turning corner	9,350

② Volumes: ATSPM data assembly

- Calculated new pedestrian activity metrics

PAM	Meaning	Definition
45B	# pedestrian calls registered (imputed)	In event sequence with just {0, 21, 90}, #90 events preceded by a 0 or 21 event
90C	# pedestrian detections (15 second filter)	In event sequence with just {90}, #90 events with ≥ 15 seconds from previous 90 event.

- Determined if phase was likely set to **pedestrian recall** for some/all of hour
- Calculated approximate **average cycle length** = hour in minutes ÷ #0 events
- Determined if signal had **high or low pedestrian activity**:
  > 350 annual average daily pedestrian activity (45B)

② Volumes: Regression modeling

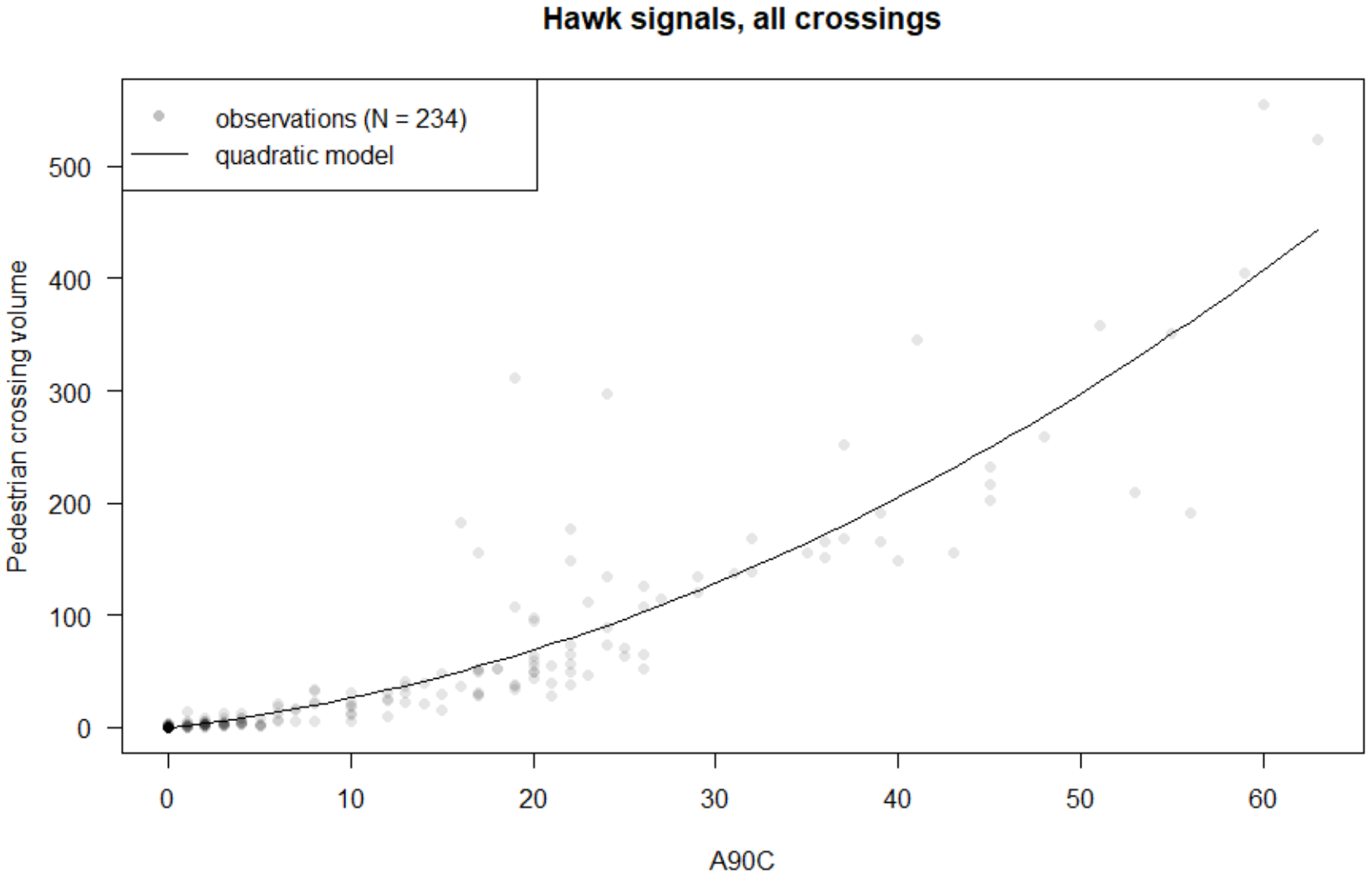
- *Model formulations*: Tested many, but final models are non-linear
  - Quadratic: $Y = b_1 \times X + b_2 \times X^2$
  - Piecewise linear: $Y = b_1 \times X + b_2 \times \max(X - br_1, 0)$

- *Outcome* (Y): Pedestrian crossing volume (by hour and crossing)
- *As predicted by* (X): Pedestrian signal activity metric (45B or 90C)
- *Segmented by*:
  - Pedestrian recall
  - High vs. low pedestrian activity
  - Average cycle length

- Criteria for "best" fitting models
  - RMSE: root mean square error (closer to 0 is better)
  - MAE: mean absolute error (closer to 0 is better)
  - Correlation (closer to 1 is better)
  - Visual inspection of plots
  - Expected model coefficients
  - Simplicity

② Volumes: Results 1

Pedestrian crossing volume = $1.790 \times 90C + 0.083 \times (90C)^2$

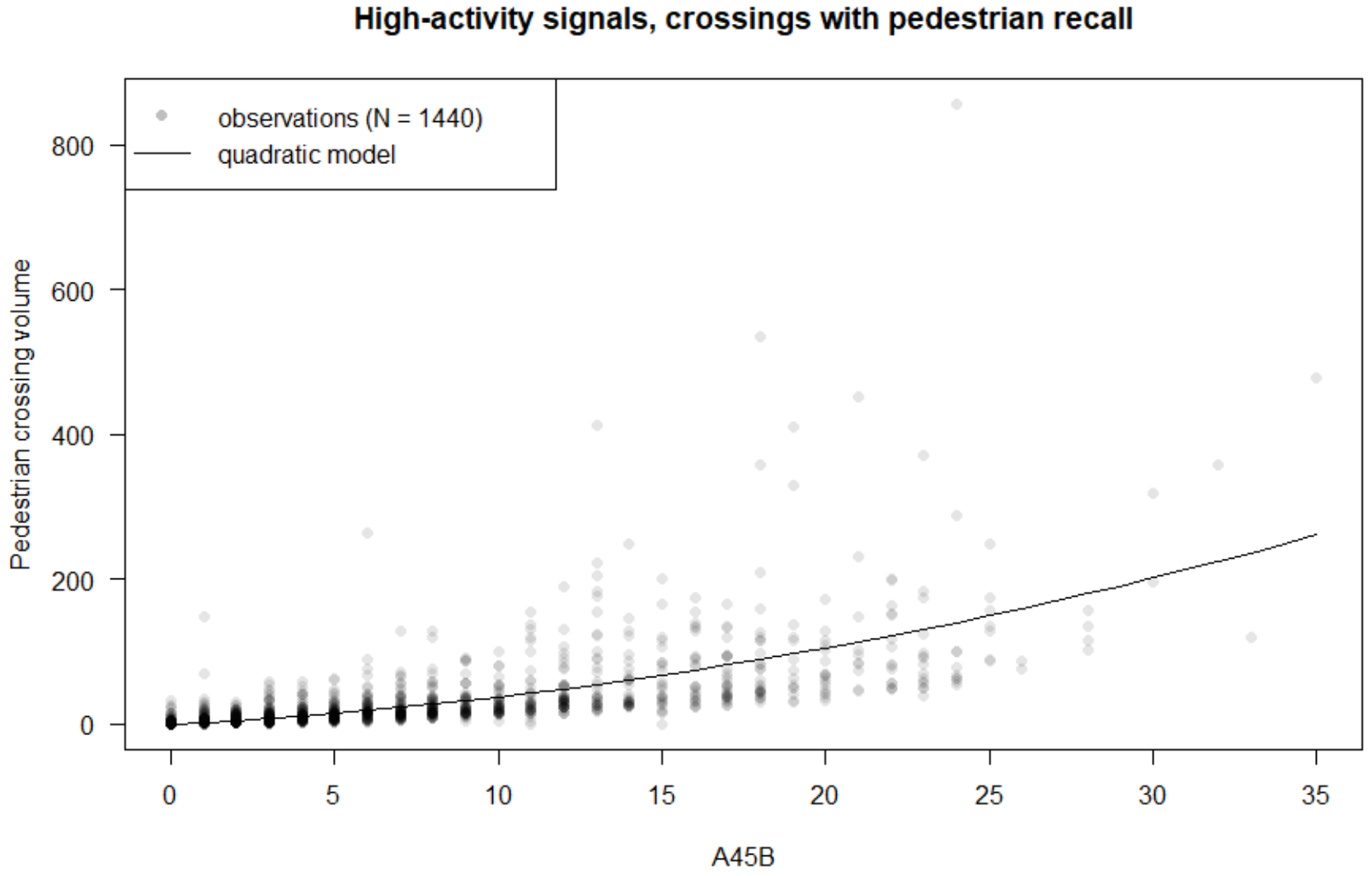


Model fit statistics

- N = 243
- $R^2 = 0.873$
- RMSE = 35.304
- MAE = 14.623
- Correlation = 0.915

② Volumes: Results 2

Pedestrian crossing volume = $2.304 \times 45B + 0.148 \times (45B)^2$

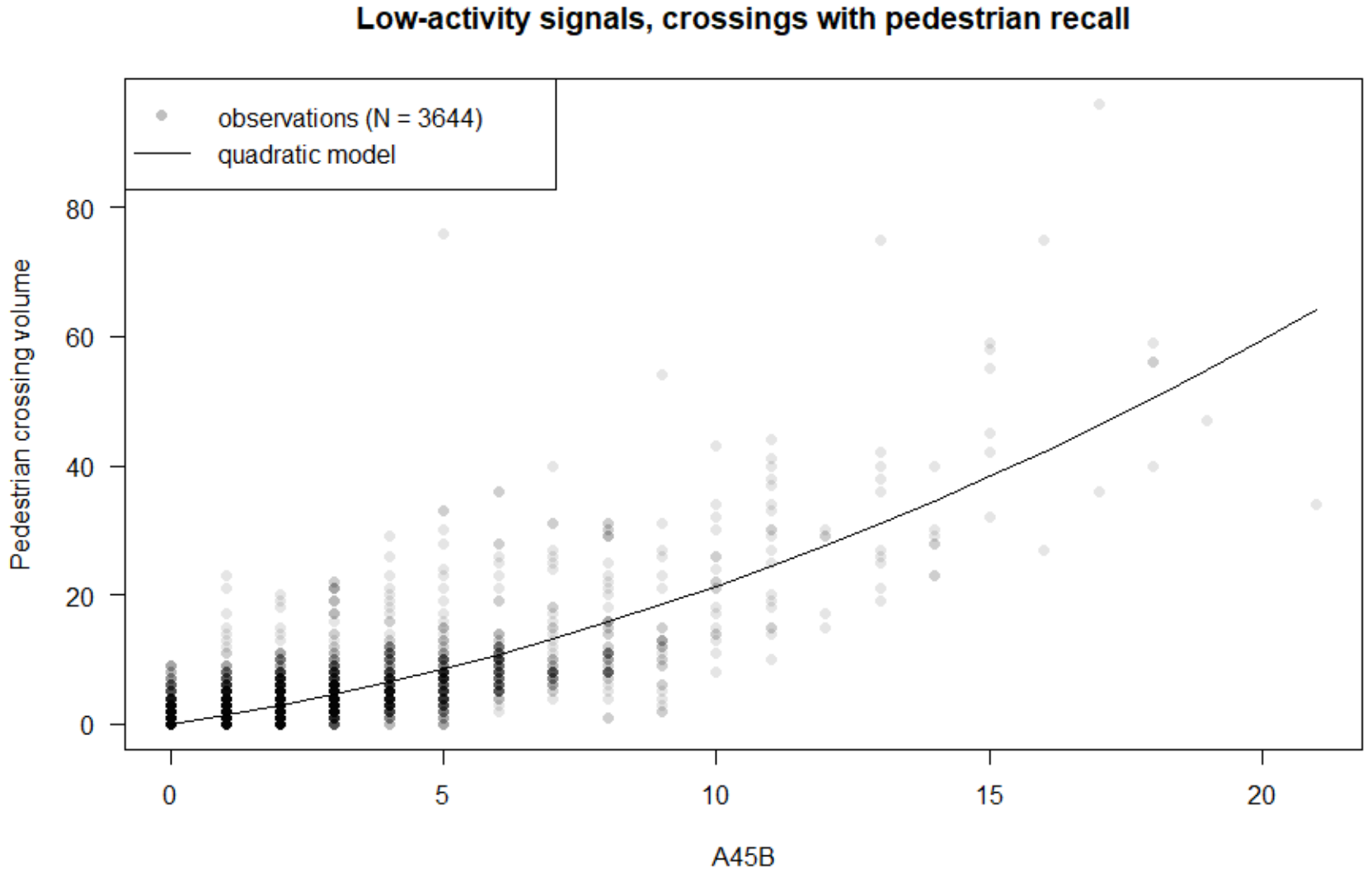


Model fit statistics

- N = 1,440
- $R^2 = 0.561$
- RMSE = 40.836
- MAE = 17.841
- Correlation = 0.649

② Volumes: Results 3

Pedestrian crossing volume = $1.310 \times 45B + 0.083 \times (45B)^2$

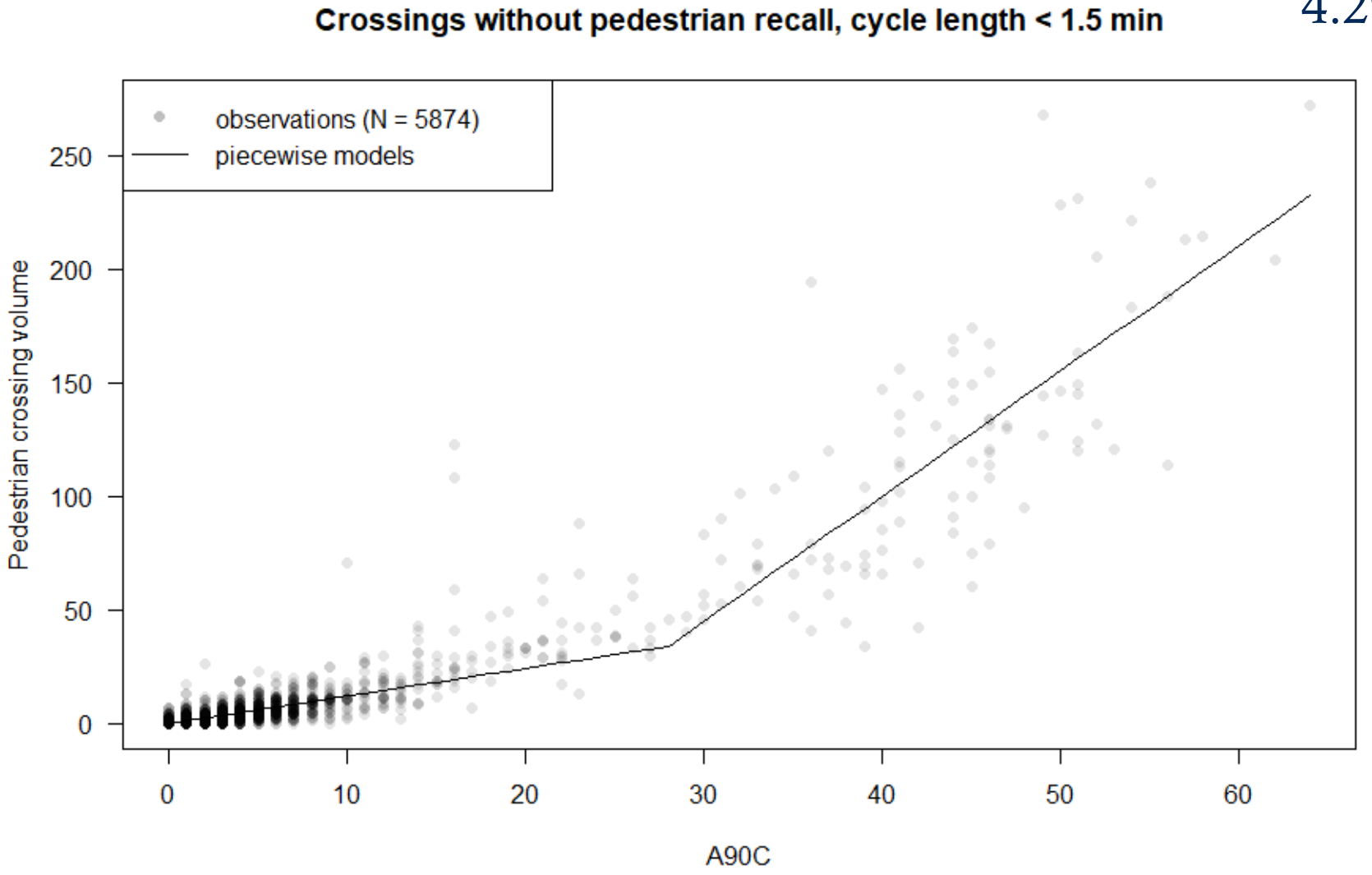


Model fit statistics

- N = 3,644
- $R^2 = 0.723$
- RMSE = 3.943
- MAE = 1.965
- Correlation = 0.804

② Volumes: Results 4

Pedestrian crossing volume =
1.215 × A90C +
4.292 × max(A90C – 28, 0)

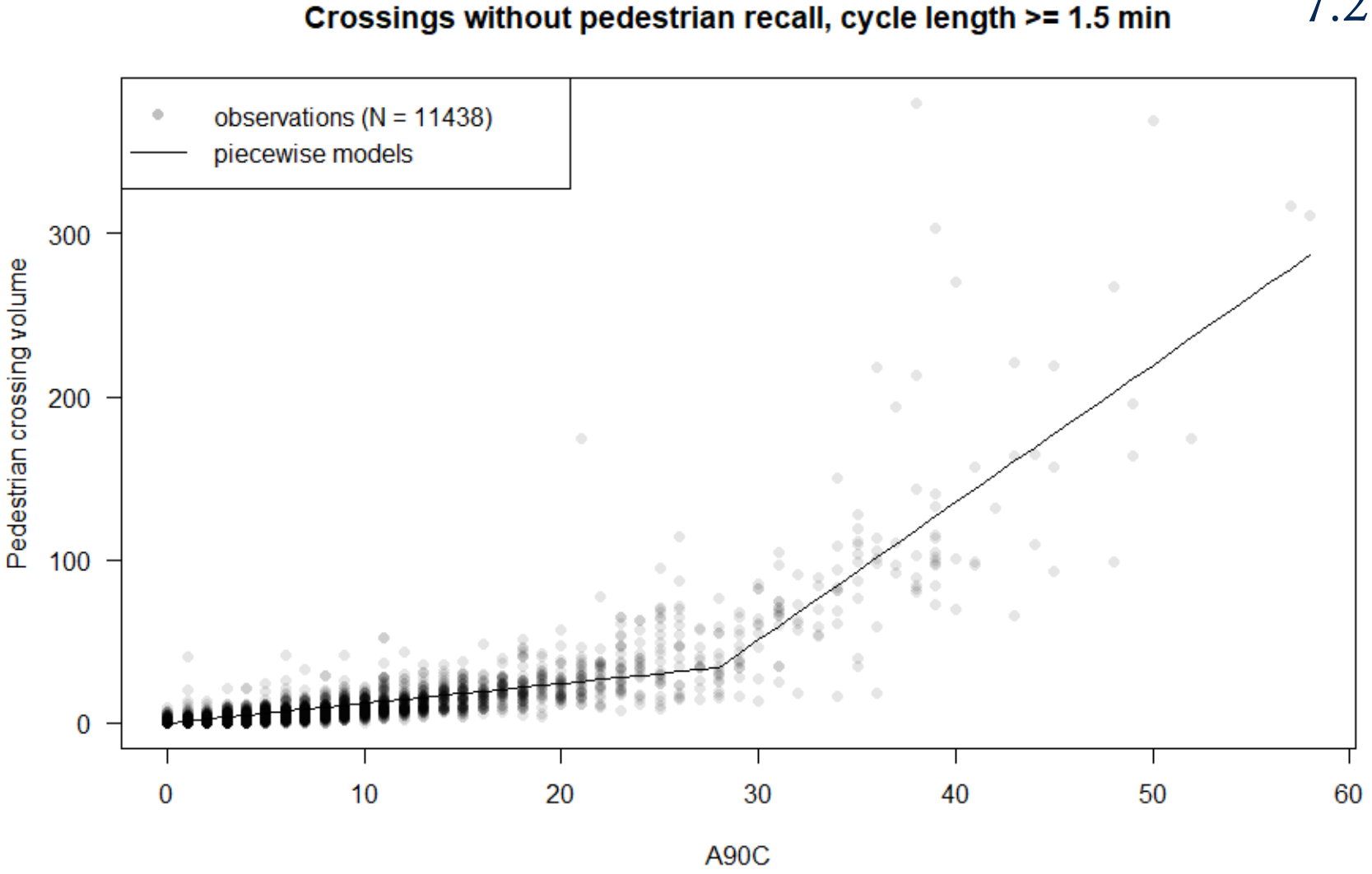


Model fit statistics

- N = 5,874
- R^2 = 0.898
- RMSE = 5.625
- MAE = 1.562
- Correlation = 0.946

② Volumes: Results 5

Pedestrian crossing volume =
1.215 × A90C +
7.214 × max(A90C – 28, 0)



Model fit statistics

- N = 11,438
- R^2 = 0.819
- RMSE = 6.332
- MAE = 1.885
- Correlation = 0.894

② Volumes: Summary of results

- Very good model fits (overall: MAE = 2.961, correlation = 0.849)
  → **Traffic signal data can be used to estimate pedestrian crossing volumes**

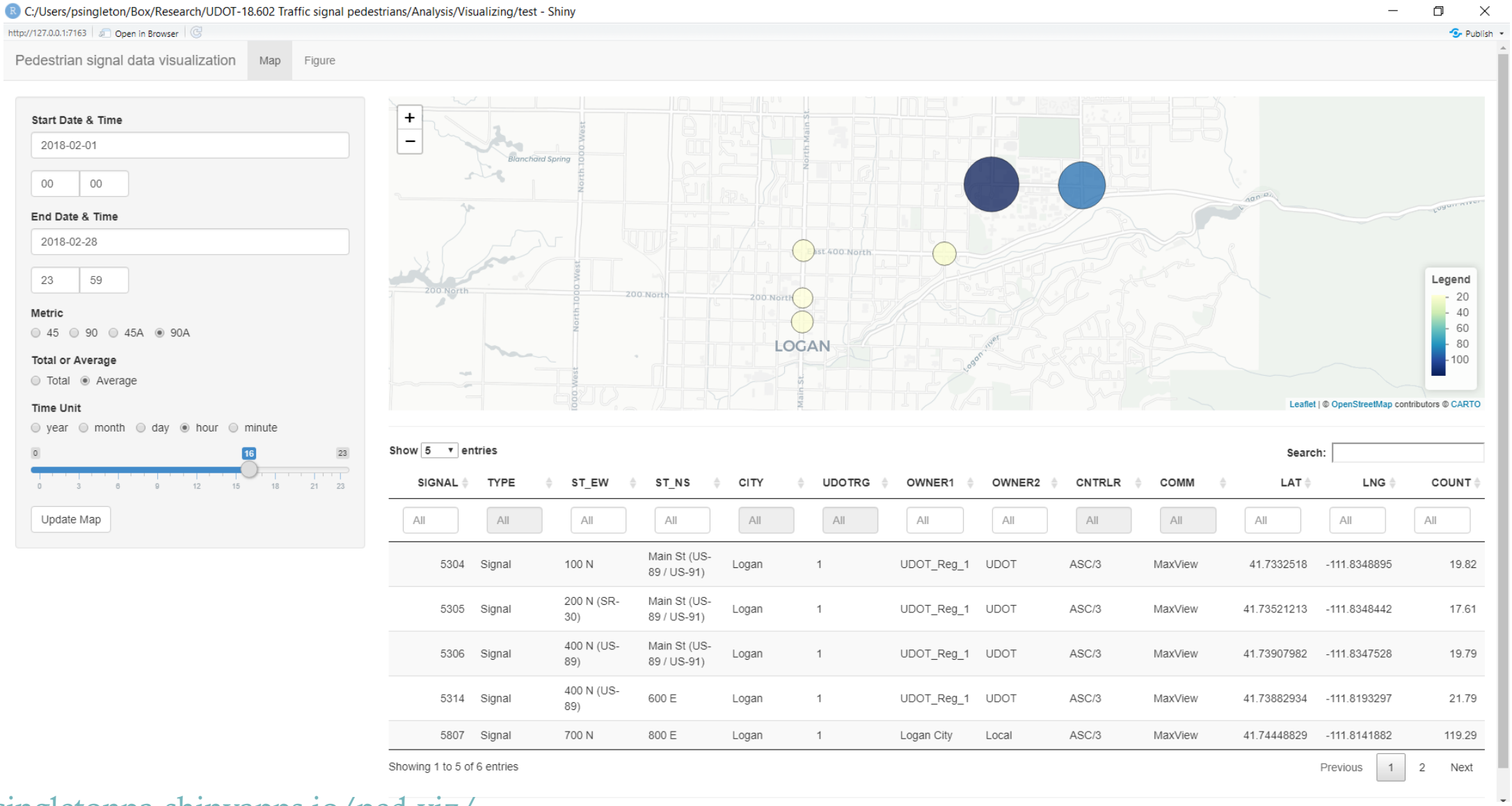
- *Non-linear relationship*: Not 1:1, so… more activity → even more pedestrians
- *Pedestrian activity*: High activity signals had larger coefficients (more people).
- *Cycle length*: Longer cycles had larger coefficients (more people waiting).
- *Pedestrian recall*: Crossings operating with pedestrian recall had worse model fits (people don't have to press the push-button). For crossings without pedestrian recall, # pedestrian detections (90C) fit best (people have to press the push-button).

② Volumes: Estimated AADP

- Applied models to one year (July 2017 – June 2018) of signal data
- Calculated annual average daily pedestrian crossing volumes (AADP)
- Top 10 locations (with pedestrian signal data)

#	Signal	Location	AADP
1	7138	S Temple & State St, Salt Lake City	6,737
2	7244	400 S & 200 E, Salt Lake City	4,868
3	7139	100 S & State St, Salt Lake City	4,519
4	7248	400 S & 600 E, Salt Lake City	4,450
5	5807	700 N & 800 E, Logan	4,446
6	8303	100 S & Main St, Moab	4,307
7	7243	400 S & Main St, Salt Lake City	4,009
8	7142	400 S & State St, Salt Lake City	3,909
9	8302	Center St & Main St, Moab	3,544
10	6631	1230 N & Canyon Rd, Provo	3,476

③ Visualize: Prototype (map)



https://singletonpa.shinyapps.io/ped-viz/

③ Visualize: Prototype (figure)

https://singletonpa.shinyapps.io/ped-viz/

③ Visualize: COVID dashboard (info)

Utah Pedestrian Activity | Information | Map of many signals | Figure of one signal

Monitoring pedestrian activity in Utah in the time of COVID-19

Updated 2020-06-18

This website provides data and visualizations of pedestrian activity (and changes in pedestrian activity) at various (signalized) intersections throughout Utah. **Currently, around 150 locations are available** (mostly clustered near Salt Lake City, Ogden, Provo, Logan, St. George, and Moab), but more are being added weekly upon request. Data are derived from pedestrian push-button presses at traffic signals, taken from the Utah Department of Transportation's Automated Traffic Signal Performance Measures System website. We hope that this information is useful for public agencies to track changes in walking activity at different (types of) locations, in order to inform crowd management efforts in public spaces and decisions about travel restrictions and stay-at-home orders and directives.

Recent results

During the week of 2020-06-07 – 2020-06-13

pedestrian activity in Utah was...

down 46%	at 149 signals in	ENTIRE STATE	
down 54%	at 78 signals in	SALT LAKE	County
down 59%	at 47 signals in	DOWNTOWN	areas
up 59%	at 8 signals in	TRAIL	areas

versus last year: 2019-06-09 – 2019-06-15

How to use

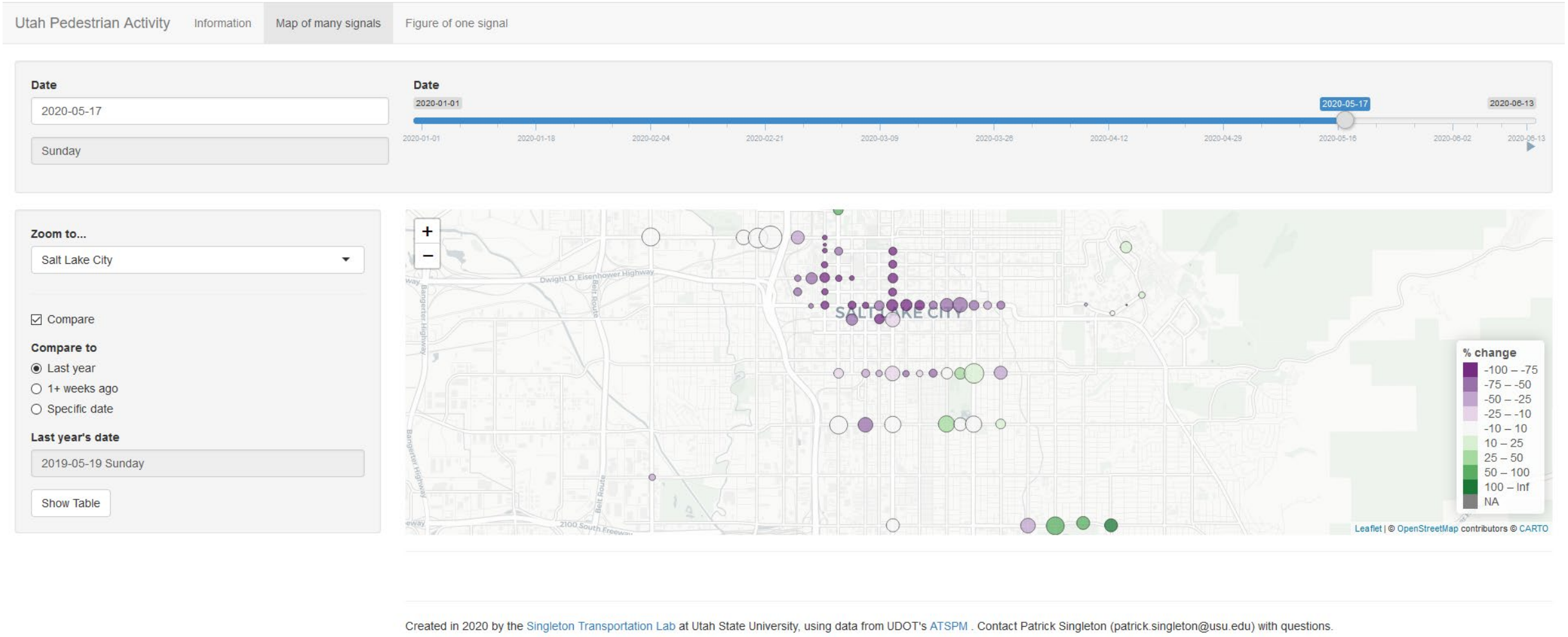
Notes

Acknowledgements

Created in 2020 by the Singleton Transportation Lab at Utah State University. Contact Patrick Singleton (patrick.singleton@usu.edu) with questions.

https://singletonpa.shinyapps.io/ped-covid19/

③ Visualize: COVID dashboard (map)



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③ Visualize: COVID dashboard (figure)

Utah Pedestrian Activity | Information | Map of many signals | Figure of one signal

Signal ID

8302

Signal ID & Location

8302 -- Center St Main St (US-191), Moab

Start Date

2020-03-01

End Date

2020-06-13

☑ Compare

Compare to

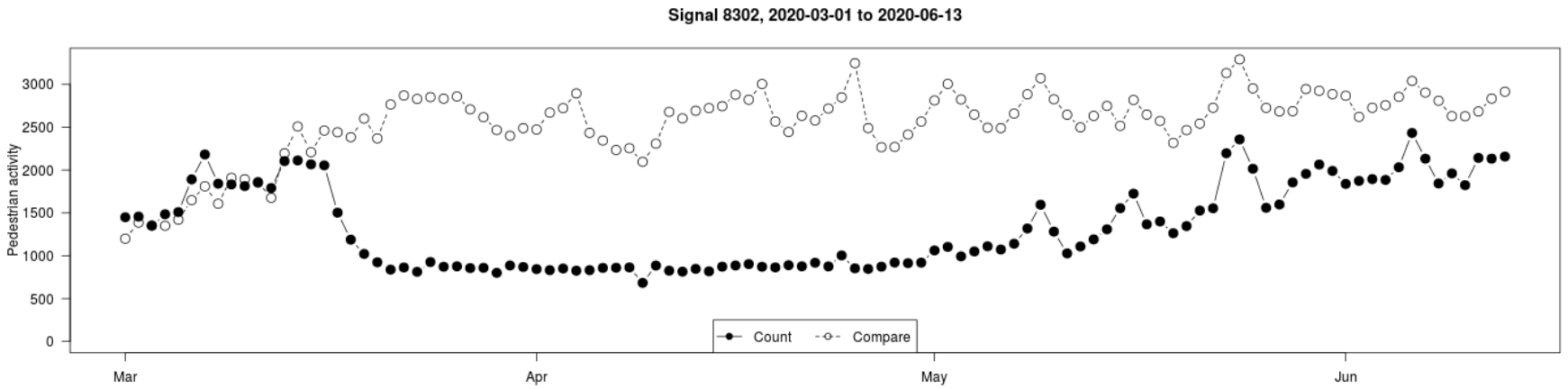
- ◉ Last year
- ○ 1+ weeks ago
- ○ Specific dates

Last year's dates

2019-03-03

2019-06-15

Create Figure & Table



2055 for 2020-03-16

Show 7 entries Search:

DATE	WEEKDAY	COUNT	COMPARE	PCTCHANGE
All	All	All	All	All
2020-03-01	Sunday	1449	1199	21
2020-03-02	Monday	1457	1387	5
2020-03-03	Tuesday	1350	1353	0

https://singletonpa.shinyapps.io/ped-covid19/

Recommendations & implementation

- Apply models to pedestrian signal data and estimate pedestrian volumes
  - Measure of **exposure** in pedestrian **safety** analysis → project UT19.316
  - Associate with **built environment** characteristics to develop "direct-demand" pedestrian volume model for **non-signalized intersections** → project UT19.504
- Future research
  - Associations with weather & air quality
  - Pedestrian factor groups
- Implementation
  - Make automated linkages between ATSPM data, processing scripts, & visualizations
  - Improve data processing scripts (missing data, stuck push-buttons, etc.)

Questions?

Patrick A. Singleton
patrick.singleton@usu.edu
435-797-7109

Ferdousy Runa
runa.ferdousy@usu.edu

Prasanna Humagain
prasanna.hmg@usu.edu