The Future of E-Bikes on Public Lands

Literature Review & Field Study

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Goals of the Study

This research study is intended to serve as:

1. A **framework** for organizing existing knowledge
2. A **roadmap** to direct future field research
3. A **framework** for documenting future knowledge

The Future of E-Bikes on Public Lands

Literature Review

Study Methodology

WFL and Volpe convened two separate groups to inform this study

- **Technical Review Group**
  - Federal, State, and local public land managers and academic researchers
  - Over 20 individuals participated
- **Stakeholder Group**
  - Representatives from various national / regional / local public lands user groups
  - Over 30 individuals participated

Study Methodology

The TRG and Stakeholder Group helped the study team craft and organize 60 research questions within four focus areas:

1. Ecological, Cultural, and Historical Resources
2. Safety factors
3. Social factors
4. Processes for E-Bike Management

Check out the final report

Many research gaps remain

Study Methodology Framework

Focus Area	Issue Area
1. NATURAL	1.1 Natural Surface Trail Condition and Wildlife
	1.2 Historical and Cultural Resources
	1.3 Mode Shift and Environmental Benefits
2. SAFETY	2.1 E-Bike-Related Injury
	2.2 Emergency Response
3. SOCIAL	3.1 Education and Communication to Trail User Groups
	3.2 Visitor Use
	3.3 Equity and Accessibility
	3.4 Keeping Up with Evolving Technology
	3.5 Expanded E-Bike Access and Existing Uses
4. PROCESS	4.1 User-Purpose-Place Alignment
	4.2 Multi-Agency Coordination

Literature Review Gap Evaluation

	D. Will there be a need to offer additional facilities or resources to support increased access to public lands (e.g., more trailhead parking, additional restrooms, and trash collection maintenance)?	None
	A. Are e-bikes legally considered "Other Power Driven Mobility Devices" under prevailing Federal ADA guidelines?	Significant
	B. How can e-bikes increase access to public lands for individuals with mobility impairments or others who are unable to effectively use conventional bikes or nonmotorized methods of access?	Significant
3.3 Equity and	C. How does e-bike use affect people with visual and hearing	

Summary of Key Findings

- Based on:
  - Comprehensive literature review
  - Summary of conversations with public lands managers and stakeholders
  - Research gap analysis

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Findings: Ecological, Cultural & Historical Resources

- Cultural/historical: very little research on whether e-bikes have different impacts
- Ecological: Only one significant study on impacts of eMTBs on natural surface trails (2016)
  - It demonstrated no significant difference in soil displacement between eMTB and conventional bikes
  - Additional experimental research is needed to better understand the impacts e-bikes may have on such trails
- Greenhouse gas reduction: Possibly, but depends on the mode the e-bikes replace

Findings: Safety factors

- Some data and studies point toward higher speeds and rates of injury in e-bike users
- E-bikes have potential as emergency response vehicles

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Findings: Social factors

- E-bikes require less physical exertion
  - Allow people to ride farther or longer
  - Increase potential benefits and impacts of bicycle use in public lands
  - Potential to change visitor use patterns
  - Could support individuals with mobility impairments or older populations
- High cost of e-bikes is barrier to ownership (equity)
- Some public lands users fear interactions with e-bikes on public lands
- Rental E-bikes may be used by novice riders who are unfamiliar with e-bike operation and safety

Findings: Processes for E-Bike Management

- There is limited published information on agency coordination of managing e-bike use
  - Recurring coordination and stakeholder engagement is valuable
- Do e-bikes warrant different trail design standards? https://www.americantrails.org/resources/emtb-land-manager-handbook
  - Some groups assert they do not
  - Further research is needed

Application to Gateway Communities and Access to Public Lands

- Changes in public land usage patterns could affect gateway communities in good and bad ways
- Public lands management agencies need science-based research and data in a variety of contexts to help inform policy decisions

The Future of E-Bikes on Public Lands

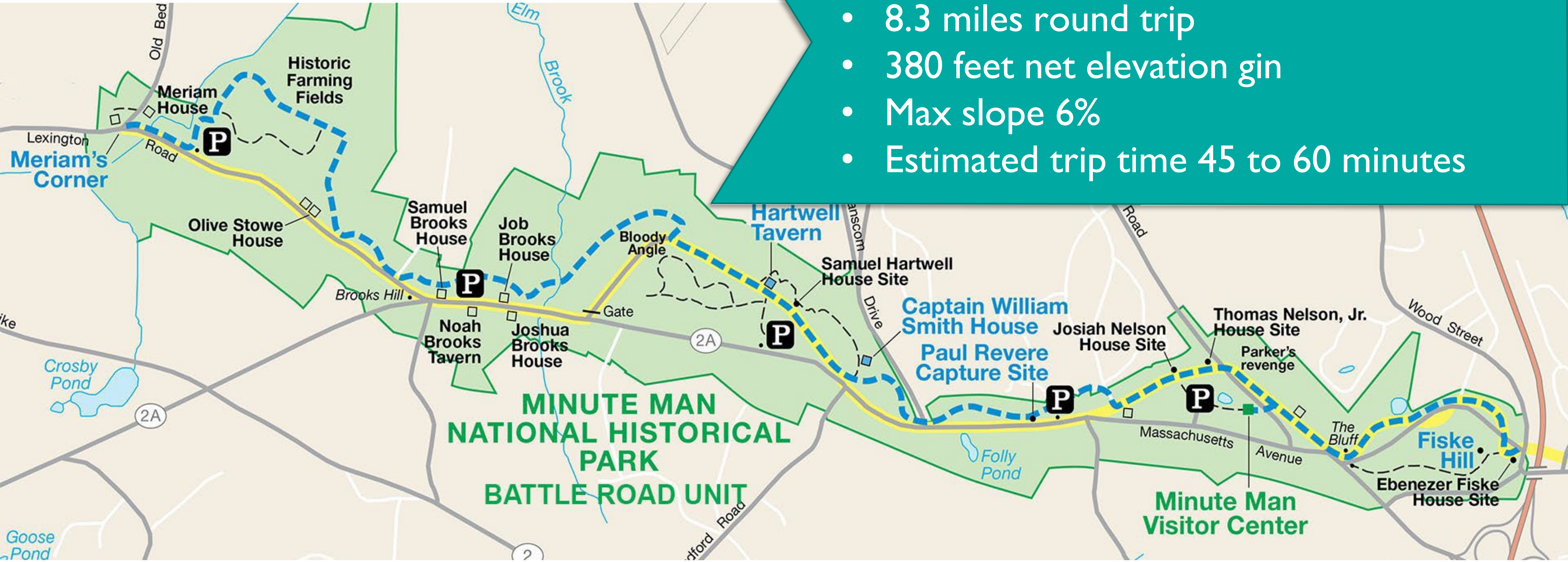
Field Study Results

Jonah Chiarenza, Volpe Center
Ian Berg, Volpe Center
Kirby Ledvina, Volpe Center
Jared Young, Volpe Center

Michael Rodriguez, Carnegie Mellon University
Robert RJ Rittmuller, Volpe Center
Dr. Daniel Flynn, Volpe Center
Clark Calabrese, Volpe Center

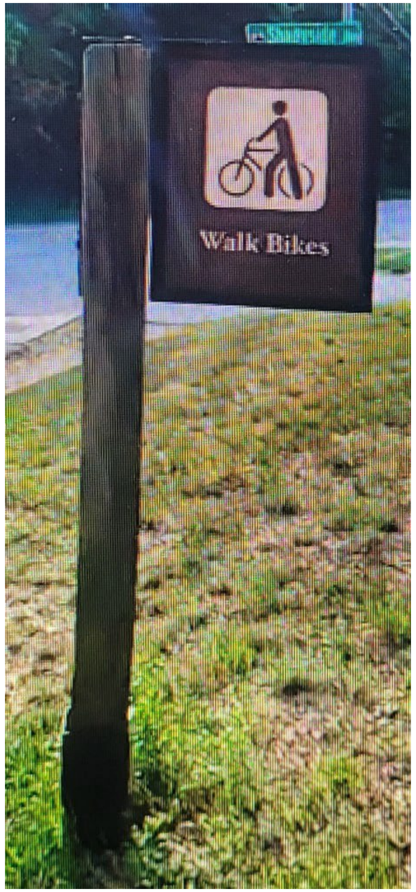
Field Study - Route

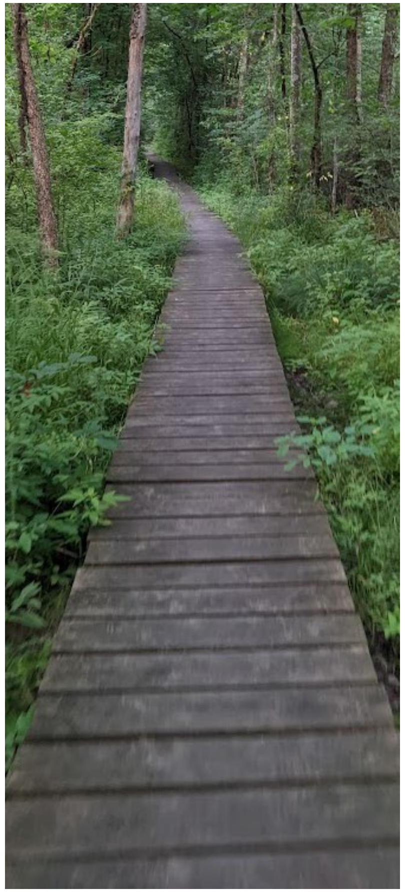
- Crushed stone, dirt, gravel trail surface
- Varied width between 6 feet and 20 feet
- 8.3 miles round trip
- 380 feet net elevation gin
- Max slope 6%
- Estimated trip time 45 to 60 minutes



Telematics Review Protocol

- Designated Segments
  - Blind Turns
  - Constrained / Narrow
  - Trail Hazard
  - Trail Junction
  - Vehicle Conflict Point
  - Uphill / Downhill

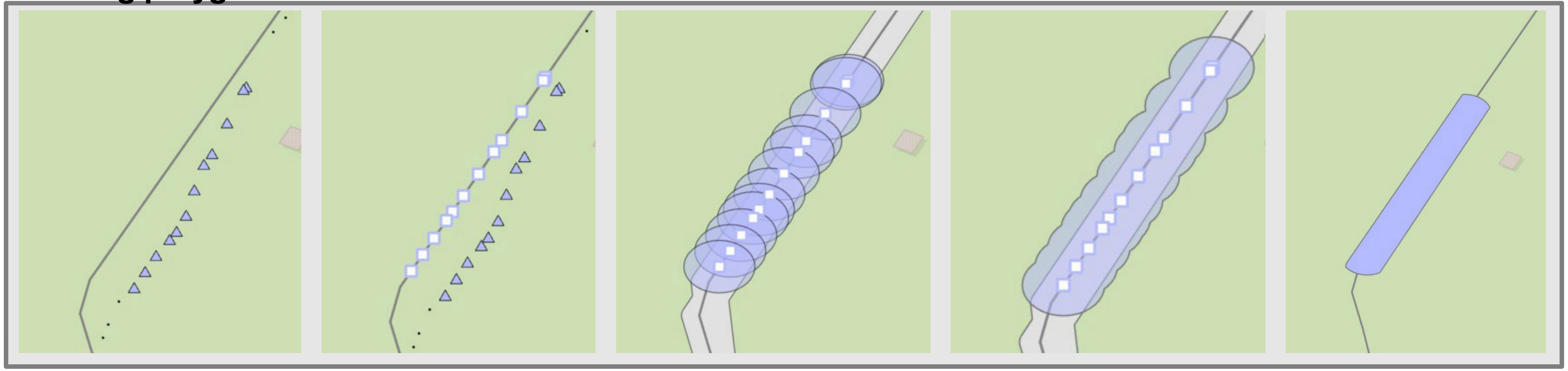




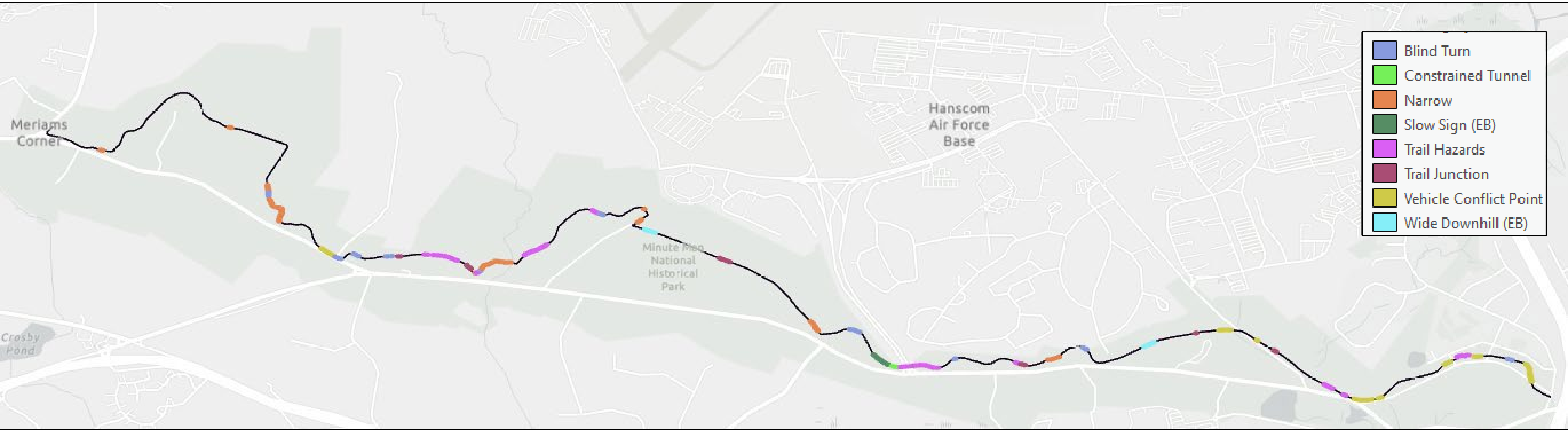
Data Processing Methodology

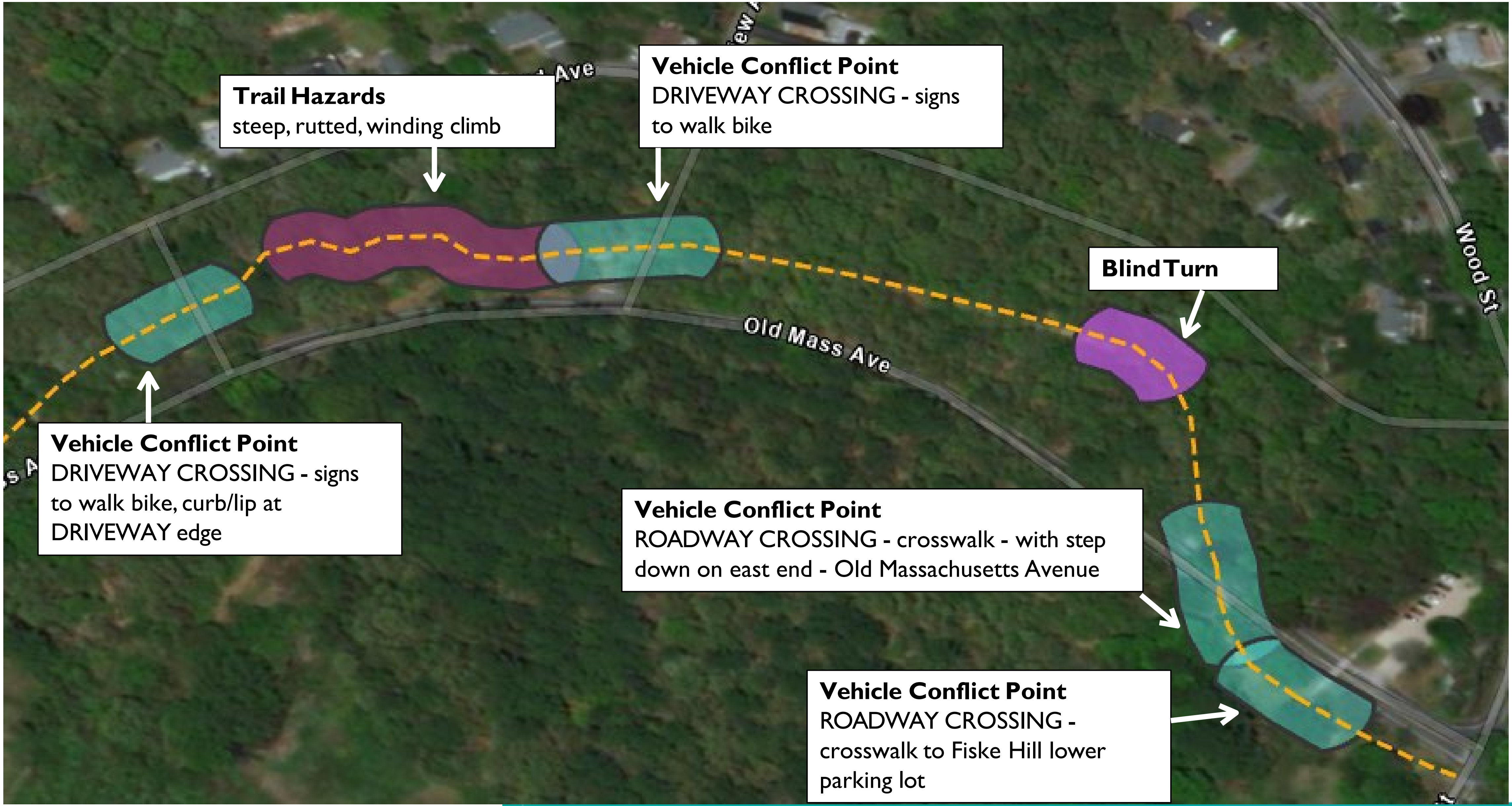
1. **Create polygons:** Use GPS pings and annotated time windows from a reference participant to create geospatial polygons for areas of interest along the trail (e.g., blind turns, vehicle conflict points, narrow sections)
2. **Extract participant GPS pings:** Select all participant GPS pings located within polygons (after some quality filtering). Conduct **quantitative** analysis.
3. **Extract participant timestamps:** List all participant timestamps for entering and exiting each polygon. Conduct **qualitative** video analysis

Creating polygons

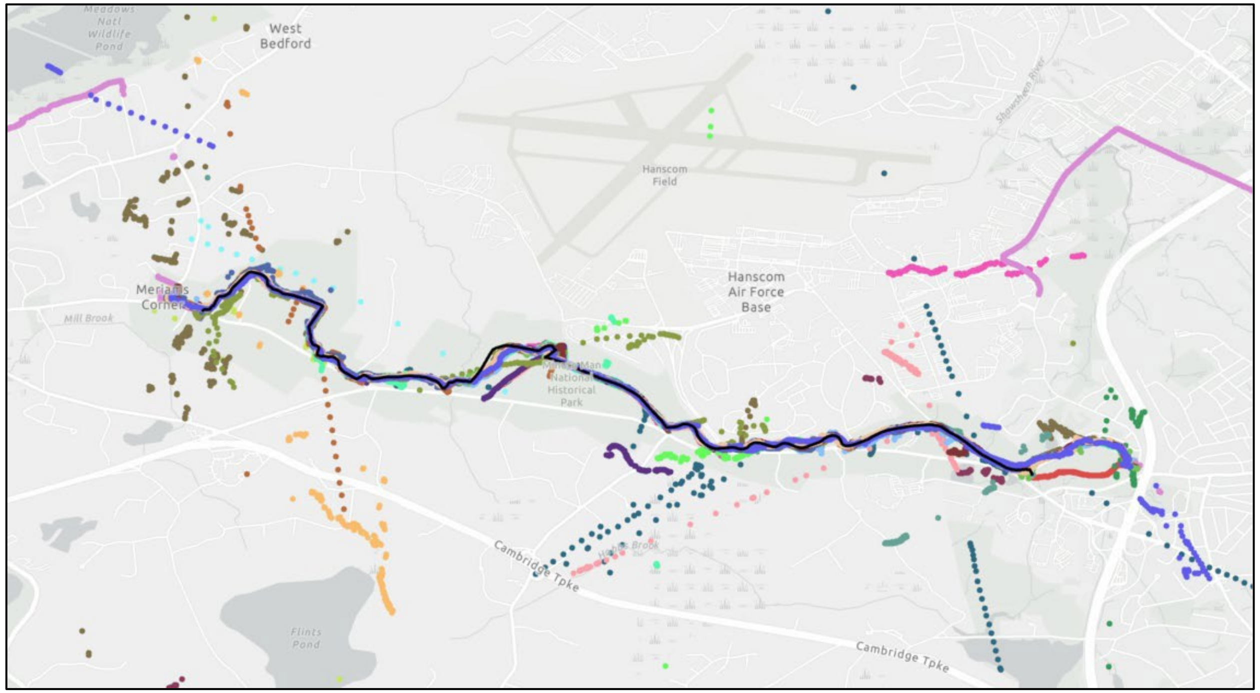


Coded Zones


Meriams Corner
Hanscom Air Force Base
Minute Man National Historical Park
Crosby Pond
Blind Turn
Constrained Tunnel
Narrow
Slow Sign (EB)
Trail Hazards
Trail Junction
Vehicle Conflict Point
Wide Downhill (EB)


Trail Hazards
steep, rutted, winding climb
Vehicle Conflict Point
DRIVEWAY CROSSING - signs to walk bike
Vehicle Conflict Point
DRIVEWAY CROSSING - signs to walk bike, curb/lip at DRIVEWAY edge
Blind Turn
Old Mass Ave
Wood St
Vehicle Conflict Point
ROADWAY CROSSING - crosswalk - with step down on east end - Old Massachusetts Avenue
Vehicle Conflict Point
ROADWAY CROSSING - crosswalk to Fiske Hill lower parking lot

GoPro Lessons Learned



Source: GoPro

- GPS in camera may take some time (~10 min?) to get a fix on location

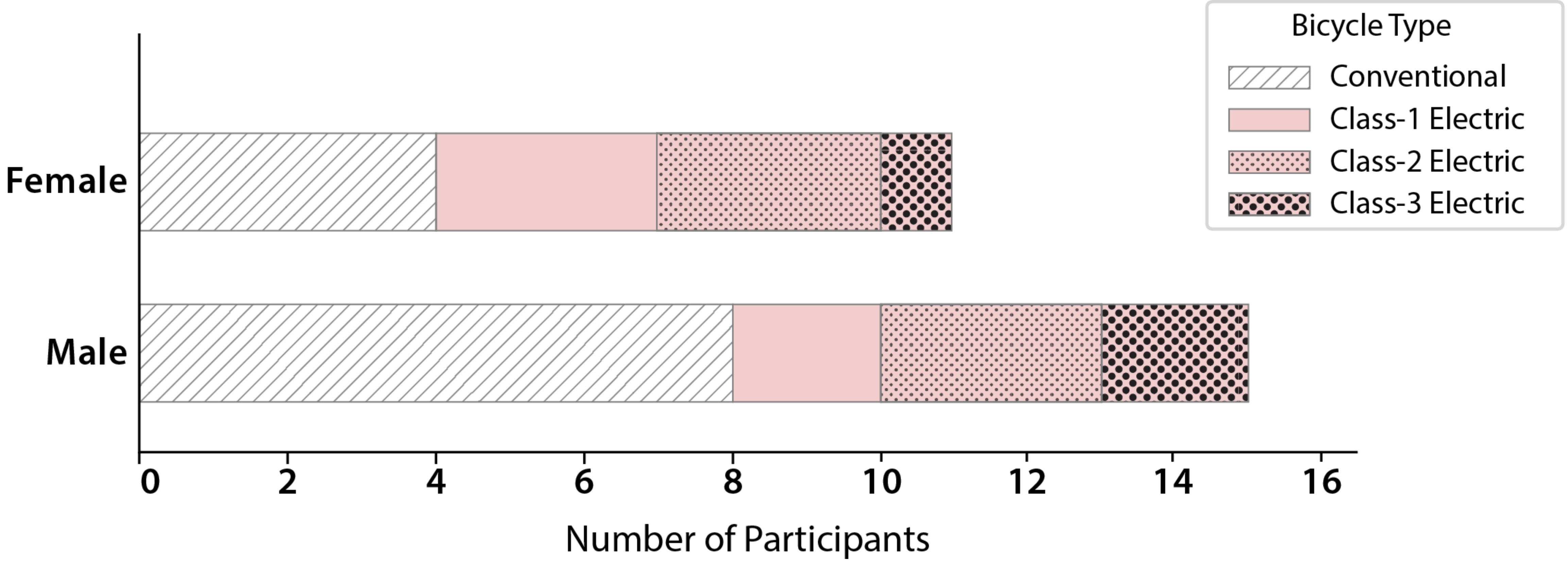
- Ensure camera faces same direction for all participants

Study Participants

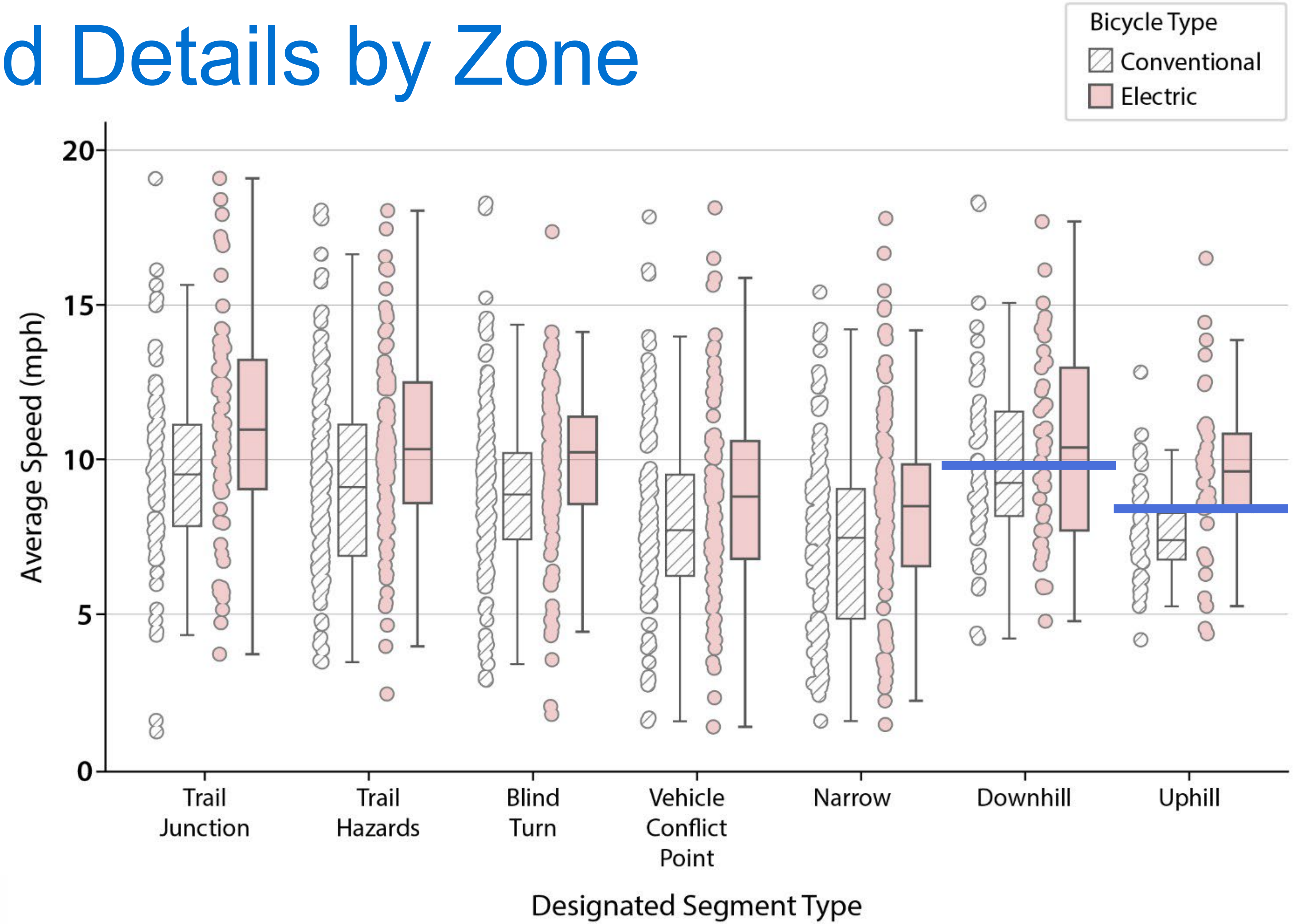
Class-I: Pedal assist only to 20 mph

Class-II: Pedal assist + Throttle to 20 mph

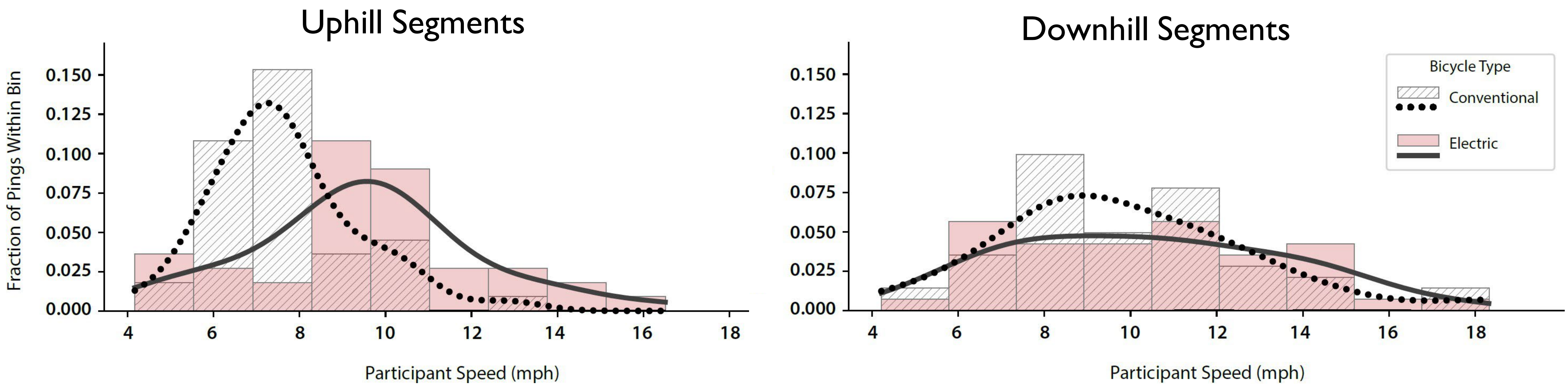
Class-III: Pedal assist only to 28 mph



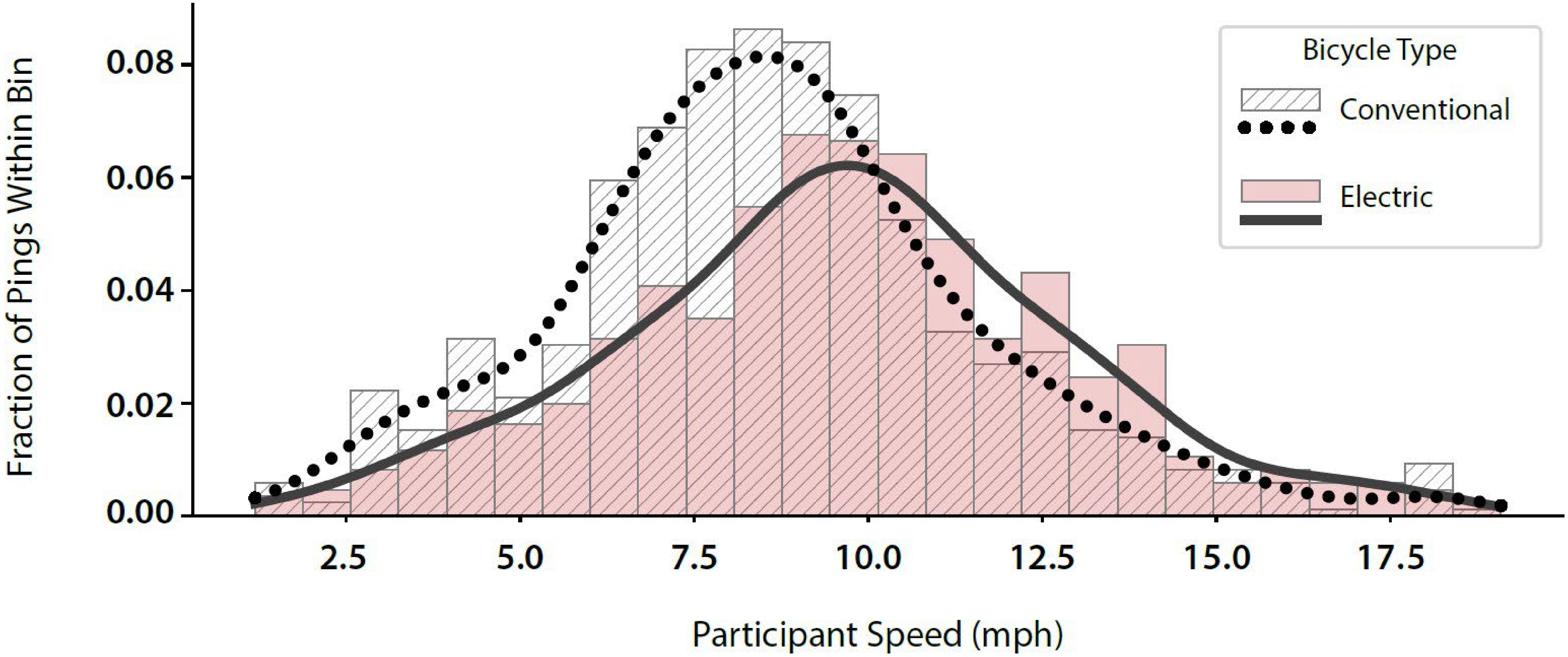
Speed Details by Zone



Relative Speed Distribution



Relative Speed Distribution

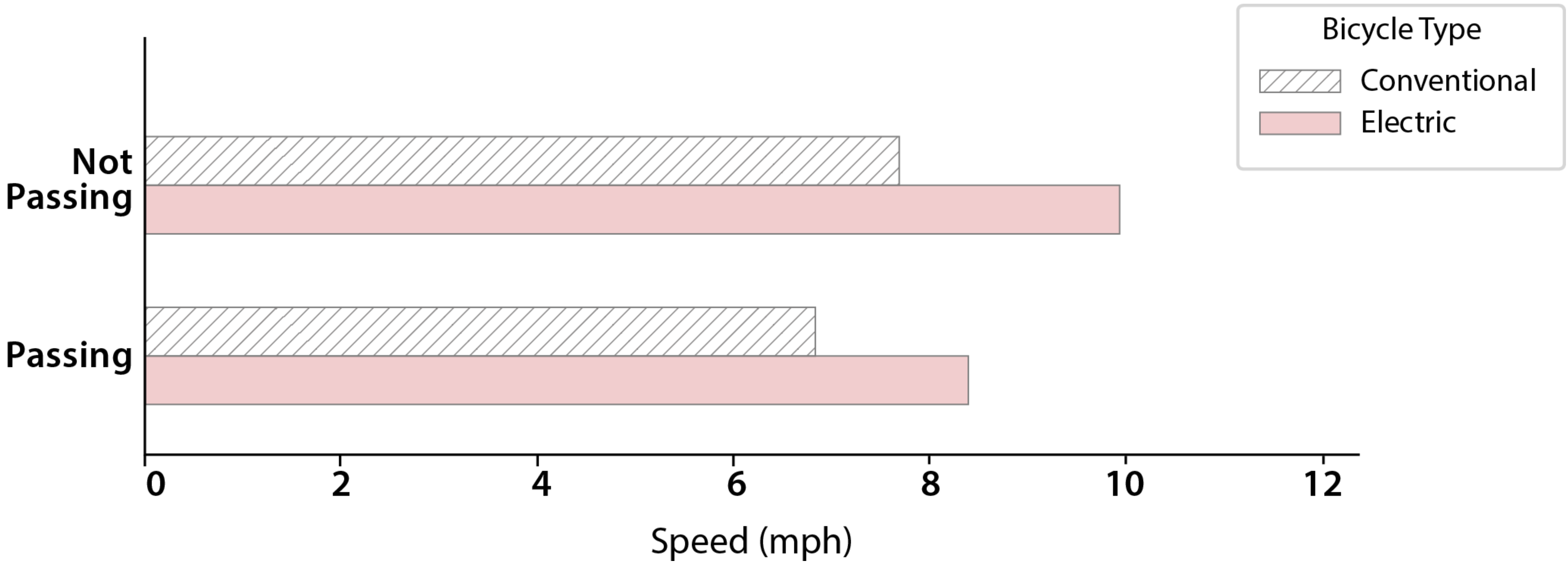


Regression Analysis

	Estimates (Speed, in mph)	Confidence Interval	P-Value
Predictors			
(Intercept)	7.91	6.52 to 9.29	<0.001
bike type [electric]	2.19	0.77 to 3.61	0.002
sex [male]	2.51	1.08 to 3.93	0.001
age centered	-0.01	-0.07 to 0.05	0.694
Uphill	-1.05	-1.08 to -1.03	<0.001
Downhill	0.38	0.36 to 0.41	<0.001
Blind Turn	0.02	-0.01 to 0.06	0.174
Narrow	-3.33	-3.36 to -3.30	<0.001
Trail Hazards	-0.33	-0.36 to -0.30	<0.001
Trail Junction	0.29	0.23 to 0.35	<0.001
Vehicle Conflict Point	-2.14	-2.18 to -2.10	<0.001
Walk Bike Sign	-2.92	-3.07 to -2.78	<0.001
Passing [1]	-1.13	-1.17 to -1.10	<0.001
Bike type [electric] *			
Passing [1]	-0.38	-0.43 to -0.33	<0.001

Regression Analysis: Passing Behavior

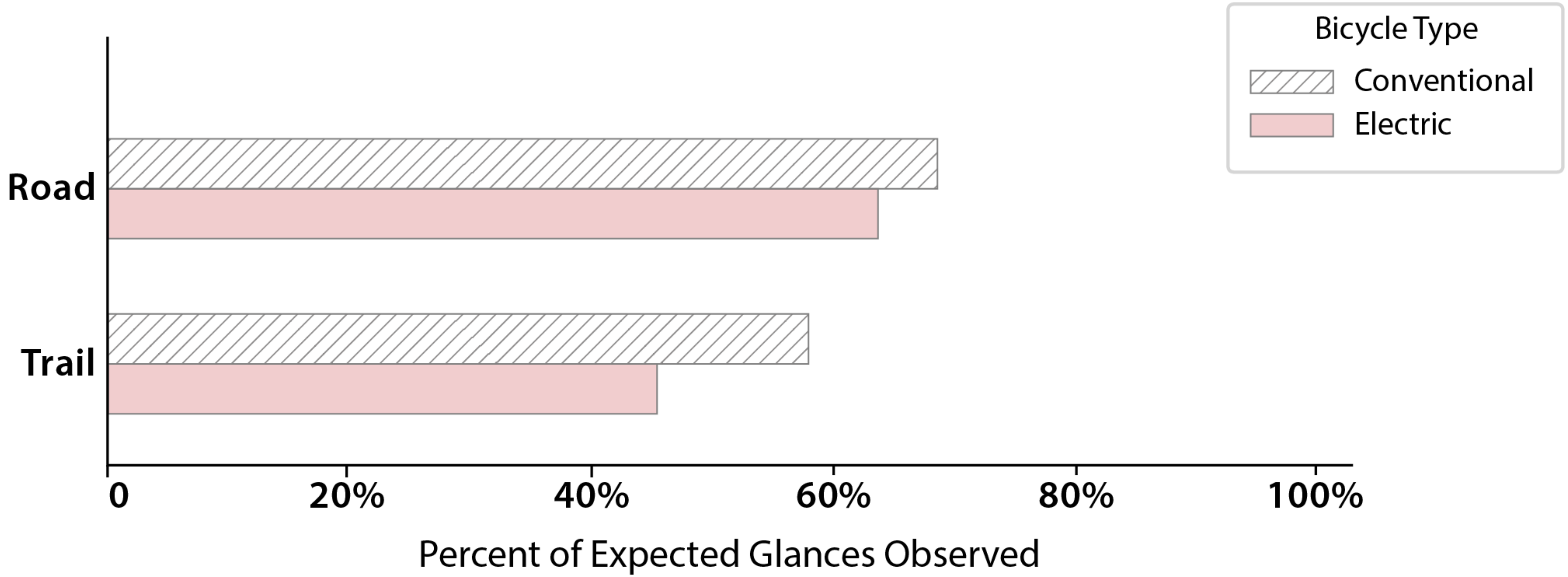
Not passing and passing speed of riders overtaking other trail users



Video Analysis: Observational Results

- Trail Junctions
- Vehicle Crossings

Video Review: Glance Behavior



Conclusions

- On average, e-bike riders travel faster than conventional bike riders
  - ~1 mph faster per T-tests
  - ~2 mph faster per regression analysis
- Distributions of e-bike and conventional bike riders overwhelmingly overlap
  - Large range of speeds among both types
  - Similar extremes at the high and low end among both types
- E-bike and conventional bike riders exhibit similar behavior at conflict-risk locations
  - Similar speed reduction at conflict points
  - Similar glance behavior at conflict points

Next Steps

- Many Desk Review questions remain unanswered
- WFL and Volpe to undertake additional field studies in FY24
  - Focus on eMTB on natural surface road and trail networks
  - Partnerships with land managers for field studies:
    - Pennsylvania Department of Conservation and Natural Resources
    - DOI Bureau of Land Management

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Thank you!