



Bike/Ped Data Collection and Model Calibration

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Kentucky Transportation Center
College of Engineering, University of Kentucky, Lexington, Kentucky

in cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky

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Research Report

KTC-26-03

Bike/Ped Data Collection and Model Calibration

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16. Abstract Motivated by an uptick in pedestrian and bicycle traffic, as well as the inclusion of pedestrian and bicyclist weights in the Strategic Highway Investment Formula For Tomorrow, the Kentucky Transportation Cabinet (KYTC) has made significant investments in transportation facilities for nonmotorized users. Despite an intensified focus on the needs of nonmotorized users, KYTC has not yet established a formal program to track the number of people walking, biking, skateboarding, and using micromobility devices statewide. Based on a review of methods and technologies for counting nonmotorized users; analysis of counting programs established by local, state, and regional transportation agencies; and a short pilot project that compared the accuracy of manual counts to automated counts, this report advances recommendations the Cabinet may use to build a program for counting nonmotorized users. The four-day pilot project conducted in Lexington, Kentucky, found that automated counts and manual counts generated similar results — within 0.5 percent of one another over the entire study period. As KYTC prepares to roll out a counting program, it should inventory programs introduced by local governments across the state to avoid redundancies in data collection, clearly articulate the objectives of nonmotorized users counts and the purposes for which they will be used, procure durable and highly accurate equipment, identify the best locations for permanent and short-duration count stations, and pursue continuous improvement by routinely evaluating data collection to verify it is meeting program objectives. Introducing and sustaining a robust program to count nonmotorized users will help the Cabinet better understand where demand for nonmotorized user facilities is greatest and target future investments accordingly.			
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Chapter 1 Introduction

Following the resurgence of bicycling and walking in the US (1), the Kentucky Transportation Cabinet (KYTC) has deepened its investments in facilities that nonmotorized users (pedestrians, bicyclists, micromobility users) rely on. The agency now incorporates weights for bicycle and pedestrian facilities into its Strategic Highway Investment Formula for Tomorrow (SHIFT), while the *Complete Streets, Roads, and Highways Manual* (2) encourages project teams to move away from autocentric roadway designs to designs which address the multimodal transportation needs of communities. The *Bicycle and Pedestrian Master Plan* (3) provides a framework for advancing pedestrian and bicycle projects across Kentucky and provides guidance for determining where existing pedestrian bicycle facilities require improvement. KYTC has also funded the development of methods to calculate the level of demand placed on nonmotorized user facilities and estimate their socioeconomic benefits (4). Despite the surge of investments in multimodal transportation solutions, the Cabinet is not yet systematically collecting data on the number of nonmotorized users who depend on facilities tailored to their needs.

Counting the number of nonmotorized users who use a facility has multiple purposes. Usage data can help agencies quantify demand and justify new investments in active transportation (AT) infrastructure. Counting the number of nonmotorized users on trails and in natural spaces improves management, preservation, and tourism initiatives. Nonmotorized traffic counts also provide critical insights into how usage patterns vary based on time of day, day of the week, season, and different weather conditions. Usage data are similarly important for conducting risk or exposure analyses, informing Road Safety Audits, and guiding intersection control evaluations. Transportation network modeling also benefits from nonmotorized user counts. With these data, modeling can more accurately identify variations in activity based on location or facility type. This analysis, in turn, enables calculation of context-specific expansion factors, which are needed to sharpen decision making about future investments. Count data can also establish an empirical foundation for modeling future bicycle and pedestrian volumes, laying the groundwork to build a safer, more efficient transportation system for nonmotorized users (5) (6).

Based on an assessment of equipment used to perform nonmotorized user counts, a review of agency-level programs, and a short pilot study based in Lexington that evaluated the accuracy of different counting methods, this report describes steps KYTC can take to develop a robust program to track pedestrian and bicycle usage. Establishing a systematic data collection process will help the Cabinet understand demand for these facilities, determine where they should be located, and size them appropriately.

Chapter 2 Literature Review

This chapter reviews (a) methods and equipment used for nonmotorized user counts, and (b) programs around the US that count nonmotorized users. The goal of these reviews was to identify methods and technologies suitable for Kentucky and to document guidance that could facilitate program development.

2.1 Nonmotorized User Counting Methods and Equipment

This section discusses seven common methods and technologies for counting nonmotorized users (7–14). It also addresses emerging applications of artificial intelligence (AI) for data collection. Write-ups for each technology describe the equipment, list factors to consider prior to installation, and highlight strengths and weaknesses. Table 2.2 summarizes information about the seven technologies as well as less-common technologies

2.1.1 Manual Counts

Description

Manual, in-person counting involves personnel recording pedestrian and bicycle volumes using multiple tools (e.g., clicker counters, smartphone apps, traffic count boards). Manual counts often involve collecting demographic information of nonmotorized users as well as recording risky behaviors. Counts are typically conducted over a period of 1 – 4 hours, with data recorded in discrete time intervals, generally 15 minutes. This method is particularly effective for capturing screen line volumes, intersection turning movements, crossing volumes, and supplementary user characteristics. Due to minimal setup costs and adaptability across multiple settings, manual counting is a good option for expanding the range of observation sites, providing initial data points for count programs, or validating data from automated systems.

Installation Considerations

- Must determine where data collectors should be positioned to have good visibility of users.
- One data collector can record up to 200 data points per hour. Multiple data collectors are needed in high-traffic areas.
- Data collectors should take breaks every two hours to minimize fatigue (15).
- Data collectors must wear high-visibility clothing and adhere to safety protocols.

Strengths

- Can gather information on demographics and other user attributes.

Limitations

- High personnel costs and significant resource requirements.
- Appropriate for only short-duration counts.
- Potential for count errors (e.g., due to poor recordkeeping or fatigue among data collectors).

2.1.2 Video-Based Counting (Manual and Automated)

Description

Video-based counting uses footage from temporary or permanent cameras to count nonmotorized users. For manual counts, trained observers review video and count nonmotorized users, document turning movements at intersections, and record user characteristics. With automated counts, computer algorithms process footage and detect movements, typically identifying pedestrians or cyclists based on changes in the background. This method can

capture both screen line and intersection turning movement volumes using multiple cameras. Specialized software supports both manual (Count Pro) (16) and automated (Visual Cortex) (17) video-based counting.

Installation Considerations

- For manual counting applications, video cameras should be securely mounted at least 10 – 25 feet above ground level to minimize the risk of theft.
- Avoid installing cameras in areas prone to visual obstructions or glare from sunlight or streetlights.
- For automated systems, mounting cameras at higher on stable structures (e.g., utility poles) is better to establish a clear detection area of up to 150 feet.

Strengths

- Support data collection in inclement weather or at night.
- Can be used for different modes, to capture detailed information (e.g., intersection turning movements, cross-walk counts), or to conduct supplemental research (e.g., facility evaluation and user behavior studies).
- Enable data collection without data collectors being onsite.
- Video playback speed can be adjusted.

Limitations

- High labor costs for installation and maintenance.
- Cameras must be securely mounted to fixed or portable poles to prevent theft or damage.
- Video footage can be corrupted, requiring reshoots.
- Quality of counts may be affected by environmental conditions.
- All video processing must be handled by a vendor.
- Algorithms for automated detection are still underdeveloped.

2.1.3 Pneumatic Tubes

Description

Pneumatic tube systems consist of one or more rubber tubes placed across a roadway or pathway. When a bicycle crosses a tube, an air pulse is generated and sent to a detector, registering a count. In mixed-traffic environments, pneumatic tubes can differentiate between bicycles and motor vehicles by detecting variations in the air pulse intensity. For counting bicycles exclusively, bike-specific counters (BSCs) are available. General-purpose counters (GPCs), which are generally intended for motor vehicles, can be adjusted to filter out motorized vehicles. When two pneumatic tubes are positioned parallel to one another, the system can capture information on bicycle speed and travel direction. When used solely for bicycle counts, placing tubes across a bike lane minimizes exposure to motorized vehicles. If bicycle and motor vehicle data are required, tubes should be positioned across the entire roadway. Pneumatic tubes may be combined with infrared sensors in a hybrid system to count bicyclists and pedestrians.

Installation Considerations

- Install pneumatic tubes along bicycle paths where cyclists are unlikely to stop, ensuring alignment with the intended travel route.
- Avoid locations frequently exposed to street sweeping or snowplowing,
- To minimize the risk of punctured tires, locate metal fixtures outside the bicycle path or secure them with tape.
- Smaller tube diameters reduce tripping hazards and improve count accuracy.
- For GPCs, settings must be carefully configured to ensure proper classification of traffic, filtering out motorized vehicle data.

Strengths

- Portable, low-cost solution that is easy to set up and familiar to many public agencies
- Able to detect bicycle speed and direction of travel.

Limitations

- Susceptible to theft, vandalism, and wear and tear.
- Require regular maintenance.
- May lose structural integrity in very cold weather and can deteriorate under high-traffic conditions.
- Installation might require the permission of local jurisdictions, some of which prohibit the use of nails.
- Not usable during street sweeping or snowplowing.
- Only suitable for paved surfaces.
- May pose a hazard to cyclists if metal fixtures dislodge or puncture tires.
- Unable to count pedestrians.

2.1.4 Inductive Loop Detectors/Sensors

Description

Inductive loop detectors are installed either permanently beneath the pavement (embedded loops) or temporarily on the surface (using tape). Loops generate a magnetic field using a low voltage alternating current, which experiences a disturbance when the metal components of a bicycle, such as the frame, spokes, and pedals, pass over it. This disturbance is registered by a data logger, which records the count. Advanced processing methods can capture unique loop signatures, allowing for classification of vehicles based on their metal composition and size. They can detect bicycles regardless of whether they contain ferrous materials (such as iron or steel) in their frames. Agencies typically use dedicated loop detectors for counting bicycles to avoid overcounting larger vehicles. Inductive loops are suitable for permanent installations and shorter-duration counts. They are commonly used for screen line counts on paved facilities such as roadways and bike paths. Accurate detection relies on proper, site-specific placement, especially on paths with separate or mixed traffic.

Installation Considerations

- Install in mid-segment, channelized locations where cyclists are unlikely to stop and typically ride in a single file.
- Select locations where the loops can cover the entirety, or nearly all, of the bicycle facility, ensuring that cyclists cannot bypass detectors.
- Embedded loops require saw-cutting into pavement
- May require significant lead time to obtain permits, hire contractors, schedule installation, and manage traffic disruptions. The data logger is typically stored in a utility box near the facility, which may necessitate excavation work.
- Temporary loops that adhere to the surface are less invasive but may be difficult to remove after use.
- Avoid installing in locations with potential interference (e.g., high electromagnetic fields).

Strengths

- Suitable for both on-street and off-street bicycle facilities.
- Reliable, long-lasting technology familiar to most jurisdictions.
- Provide accurate bicycle counts.
- Can be battery powered.

Limitations

- Embedded loops require pavement saw cuts and a minimum pavement thickness.
- May be affected by electromagnetic interference.
- May not detect side-by-side cyclists and could generate inaccurate results for nonstandard bicycles (e.g., bicycles with trailers or cargo boxes, tandem bicycles).
- Only count bicyclists and may have bypass errors if the loop does not cover the entire path width.

2.1.5 Passive Infrared (PIR) Sensors

Description

PIR devices/sensors detect pedestrians and cyclists by measuring infrared radiation (heat) patterns individuals emit as they pass in front of a sensor (18) (19). A sensor is typically placed on one side of a facility, where it compares the background temperature to that of a person. Background heat sources, such as windows or reflective surfaces, can trigger false detections, and occlusion (e.g., one person blocking another) may produce undercounts, especially at higher volumes. These devices are well-suited for short-duration or permanent count stations in environments where pedestrians and cyclists share multiuse paths or sidewalks. Since PIR sensors cannot differentiate between pedestrian and bicycle modes, they are often paired with bicycle-only counters, such as inductive loops, to distinguish user types.

Installation Considerations

- Position sensors at vendor-specified heights (2 – 3 feet) and point them toward a stable background object (e.g., a wall).
- Avoid installing sensors where pedestrians are likely to linger or congregate (e.g., doorways, bus stops, street corners) and in areas with heavy foliage, windows, or reflective surfaces.
- Position the sensor at a 45-degree angle to a pathway to minimize occlusion errors.

Strengths

- Compact, portable, and easy to install with a low-profile, unobtrusive design, making them theft resistant.
- May be combined with other technologies to distinguish user types.

Limitations

- Cannot differentiate between pedestrians and bicyclists.
- Not suitable for mixed-traffic areas like shared or shoulder bike lanes.
- Lower accuracy in areas with extreme temperatures, pedestrian groups (occlusion error), and reflective surfaces or direct sunlight.

2.1.6 Active Infrared (AIR) Sensors

Description

AIR devices count pedestrians and cyclists using an infrared beam. When an object (e.g., a pedestrian or cyclist) breaks this infrared beam for a preset period, a detection is recorded. AIR sensors are commonly used for bicycle or pedestrian screen line counts on shared-use paths or sidewalks. Because they cannot differentiate pedestrians from cyclists when used on their own, AIR devices should be combined with bicycle-specific counting technology,

Installation Considerations

- The transmitter and receiver must be aligned precisely, especially when placed far apart (up to 90 feet).
- For permanent installations, a new post can be added to secure the equipment.

- Avoid areas where pedestrians or cyclists may stop, linger, or gather, such as doorways, bus stops, or street corners.
- Positioning devices at a 45-degree angle to the facility minimizes occlusion errors.

Strengths

- Portable, easy to set up, and have a low-profile design.
- May be combined with other technologies to differentiate between pedestrians and cyclists.
- Provide high precision with a linear error function.

Limitations

- Unsuitable for on-street or mixed-traffic monitoring.
- Can produce false positives from non-target objects, including vehicles, animals, leaves, and raindrops.
- Require stable mounting on both sides of a path.
- Tend to have increased errors when groups of pedestrians or cyclists travel side by side.

2.1.7 Piezoelectric Strips

Description

Piezoelectric strips are typically embedded across a paved travel path in pairs. When a bicycle crosses over the strips, the applied pressure generates a signal, which a data logger records. The sequence in which the strips detect pressure indicates direction; the time interval between signals allows user speed to be calculated. These sensors are employed widely for permanent bicycle counting on multiuse paths, cycle tracks, and other paved shared facilities. While they are primarily designed for bicycle counts, piezoelectric strips are an option for counting pedestrians in low-volume areas. Pedestrians can be counted using the same configuration or by adding a mat.

Installation Considerations

- Installation is a complex and invasive process that involves cutting slots into pavement to embed the strips securely.
- Often, a data logger is housed in a nearby utility box, which may require excavation for installation.
- Precision in positioning and securing the strips is critical, often necessitating guidance from the vendor, especially on resin application.
- Avoid high-traffic areas where users are likely to stop frequently (e.g., intersections) to reduce the risk of over-counting.

Strengths

- Able to capture data on speed and direction of travel.
- Discrete and not susceptible to tampering when embedded in pavement.
- Resilient to inclement weather.
- Can operate on battery or external power.

Limitations

- Not suitable for mixed-flow traffic.
- May require a specialized installation process (tools, knowledge, and potentially vendor assistance).
- Can produce errors with groups of cyclists.
- Limited availability and product options exist due to less widespread usage.

2.1.8 Hybrid Methods

Description

Hybrid methods deploy multiple sensors — typically PIR sensors alongside inductive loops — to detect and differentiate between pedestrians and bicycles in mixed-use environments. These counters are primarily used for long-term data collection on shared-use paths, sidewalks, and other multiuse facilities and are especially valuable in areas where pedestrian and bicycle traffic coexist and understanding the modal split (i.e., the proportion of pedestrian versus bicycle traffic) is crucial. They are preferred for long-term data collection rather than short-duration counts.

Installation Considerations

- Follow installation recommendations for the sensors used.

Strengths

- Can count pedestrians and bicyclists separately, minimizing mode misclassification.

Limitations

- More complex installation process.
- Higher costs than using a single type of sensor (20).

2.1.8 AI Detection

AI-based systems (e.g., CronAI Perception Detection with senseEDGE software) (21), provide real-time detection of all roadway users. By processing individual movements and through integration with intelligent traffic systems, these technologies offer 3D Lidar-based tracking to improve safety for vulnerable road users (VRUs). In 2020, California Department of Transportation (Caltrans) published a research report (22) on developing algorithms and methods to process traffic videos from existing traffic cameras using AI, machine learning, deep learning, and computer vision (see Section 2.3).

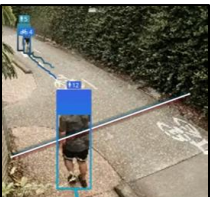
2.2 Summary of Nonmotorized Counting Methods and Technologies

Figure 2.1 summarizes key features of the methods and technologies described in this section. It specifies the user types targeted by each method/technology, use cases (i.e., short or long-duration), installation locations, cost, and advantages and disadvantages. Table 2.1 elaborates on this figure by illustrating of each technology and by covering technologies not discussed above.

Method	Users	Duration	Location	Cost	+/-
Manual			Roadway; Sidewalk; Bike lanes; Paths	\$\$	+ No installation; Other data - Count errors
Video- Manual			Roadway; Sidewalk; Bike lanes; Paths	\$\$ - \$\$\$	+ Other data; Use existing cameras - Labor cost; Camera issues
Video- Automated			Roadway; Sidewalk; Bike lanes; Paths	\$\$ - \$\$\$	+ Portability; Other data use; No human labor - Vendor processing; Weather
Pneumatic Tubes			Bike lanes; Paths	\$ - \$\$	+ Portability; Easy set up; Capture speed - Maintenance; Cold weather; Paved only
Inductive Loops		 	Bike lanes; Paths	\$\$ - \$\$\$	+ Long lasting - Detection issues; Involved set up; Bypass errors
Infrared Sensors		 	Sidewalk; Bike lanes; Paths	\$\$ - \$\$\$	+ Portability; Easy set up - User distinction; Cold weather; Location and set up
Piezoelectric Sensors			Bike lanes; Paths	\$\$ - \$\$\$	+ Capture speed and direction; No tampering - Installation; Detection issues; Paved only
Hybrid		 	Sidewalk; Paths	\$\$ - \$\$\$	+ Accuracy; User separation - Installation; Maintenance
Legend  Short term  Permanent \$ Low cost \$\$ Medium cost \$\$\$ High cost * Non distinguishable					

Figure 2.1 Graphical Summary of Methods and Technologies Used to Count Nonmotorized Users

Table 2.1 Summary of Methods and Technologies for Counting Nonmotorized Users

Technology	Users	Duration	Location	Cost	Pros & Cons	Picture
Most Popular						
Manual Counts	Ped and bikes, separately	Short	Roadway, side-walks, on/off-street bike lanes, shared-use paths	Medium to high	- Additional data - No installation needed - Labor cost - Count errors	
Video Counts — Manual	Ped and bikes, separately	Short	Roadway, side-walks, on/off-street bike lanes, shared-use paths	Medium to high	- Additional data - Traffic cameras can be used - Suitable for poor weather or at night - Labor cost - Potential camera issues	
Video Counts — Automated	Ped and bikes, separately	Short	Roadway, side-walks, on/off-street bike lanes, shared-use paths	Medium to high	- Minimal labor requirements - Accurate in high traffic - Vendor processing needed - Portable, easy setup - Multipurpose video use - Both screen line and intersection counts	
Pneumatic Tubes	Bikes only	Short	Shared road, on/off-street bike lanes, shared use-paths	Low	- Portable, easy setup - Only paved surfaces - Speed and direction - Familiar technology - Prone to theft - Needs regular maintenance - Not suitable for high traffic volumes and cold conditions	

Technology	Users	Duration	Location	Cost	Pros & Cons	Picture
Inductive Loops	Bikes only	Short or Permanent	Roadway, on/off-street bike lanes, shared-use paths	Medium to high	- Familiar technology - Durable equipment - Accurate when properly installed - Errors with groups - Moderate setup	
Passive Infrared Sensors (PIR)	Ped and bikes, combined	Short or Permanent	Sidewalks, off-street bike lanes, shared-use paths	Medium	- Portable, easy setup - Low-profile design - Not suitable for mixed traffic - Errors with groups and temperatures close to body temperature - Errors with reflections or direct sunlight	
Active Infrared Sensors (AIR)	Ped and bikes, combined	Short or Permanent	Sidewalks, off-street bike lanes, shared use paths	High	- Portable, easy setup but needed on both sides of the path - Low-profile design - High precision - Not for on-street or mixed traffic - Prone to false counts - Errors with groups	
Piezoelectric Strips	Bikes only, (also available for peds)	Permanent	On/off-street bike lanes, shared-use paths	Medium to high	- Not affected by rain or snow - Not widely used - Only paved surfaces - Speed and direction - Not suitable for mixed traffic - Errors with groups	

Technology	Users	Duration	Location	Cost	Pros & Cons	Picture
Hybrid	Ped and bikes, separately	Short (not preferable) or Permanent	Sidewalks, shared-use paths	High	- Accurate counts - Complex installation	
Other						
Thermal Imaging Cameras	Ped and bikes, separately	Short	Roadway, sidewalks, on/off-street bike lanes, shared-use paths	NA	- Multipurpose video use - Not affected by light changes	
Radio Beams	Ped and bikes, separately (with multiple radio frequencies)	Short or Permanent	Sidewalks, off-street bike lanes, shared-use paths	Medium to high	- Portable, easy setup but needed on both sides of the path - Errors with groups	
Laser Scanners	Ped and bikes, combined	Short or Permanent	Roadway, sidewalks, on/off-street bike lanes, shared-use paths	NA	- Large areas can be monitored - Errors in inclement weather - Mainly for indoor applications	
Radar	Bikes only	Short or Permanent	On/off-street bike lanes	NA	- Limited availability - In-ground installation - Not for locations where the ground freezes	

Technology	Users	Duration	Location	Cost	Pros & Cons	Picture
Pressure and Acoustic Pads	Ped and bikes, combined	Short or Permanent	Unpaved trails or shared-use paths	NA	▪ In-ground installation ▪ Require users to pass directly above the sensor ▪ Acoustic pads can only count pedestrians ▪ Not for locations where the ground freezes	
Magnetometers	Bikes only	Permanent	Rural bike paths or mountain bike trails	NA	▪ Limited availability ▪ In-ground installation ▪ Not for locations where the ground freezes ▪ Small detection area ▪ Errors with groups	
Fiberoptic Pressure Sensors	Bikes only	Permanent	Sidewalks, on/off-street bike lanes, shared-use paths	NA	▪ Suitable for high traffic volumes ▪ Not for mixed traffic	
Emerging						
3D Lidar and AI detection	Ped and bikes, separately	Short or Permanent	Roadway, sidewalks, on/off-street bike lanes, shared-use paths	NA	▪ Minimal labor requirements ▪ Accurate in high traffic ▪ Vendor processing needed ▪ Portable, easy setup	

2.3 Agency Pedestrian and Bicyclist Count Programs

Many agencies across the US have established pedestrian and bicyclist count programs. This section describes 24 initiatives — 11 at the state level, 13 at the local or regional levels. Appendix B provides a detailed summary of each program. Most state-level programs have drawn from the National Bicycle and Pedestrian Documentation Project (NBPDP) methodology (15).

2.3.1 California Transportation Department (Caltrans)

A Caltrans-sponsored research project evaluated the use of deep learning and AI for monitoring pedestrians and cyclists. Researchers developed AI-based algorithms and methods for processing videos captured using traffic cameras, machine/deep learning, and computer vision to monitor, recognize, track, and count pedestrians and cyclists (22, 23).

Caltrans Active Transportation Counts (ATRC) is working with UC Berkeley SafeTREC to develop a count methodology that can be used statewide and to expand the Southern California Association of Governments' regional active transportation database to cover a statewide user base. They will develop standardized guidance for collecting bicycle and pedestrian counts. Guidance will include methodologies for manual and automated counts and a methodology to determine project-level counts for ATP projects (24).

2.3.2 Colorado Department of Transportation (CDOT)

CDOT (25) installed its first permanent-count stations in 2010. Today, the program maintains permanent and short duration monitoring sites throughout the state. Data from permanent monitoring sites are used to establish seasonal and daily factors for extrapolating short-duration counts. As of 2024, 16 permanent-count stations were in operation (26). CDOT has employed several types of installations at permanent monitoring sites. Inductive loops are the most common and are installed at 20 of the 24 sites. Loop counters have been installed in conjunction with PIR sensors in some locations so CDOT can track pedestrian and bicycle activity separately. CDOT and local agencies also conduct shortduration counts at multiple locations. Statewide, counts have been conducted at 187 sites (Figure 2.2).

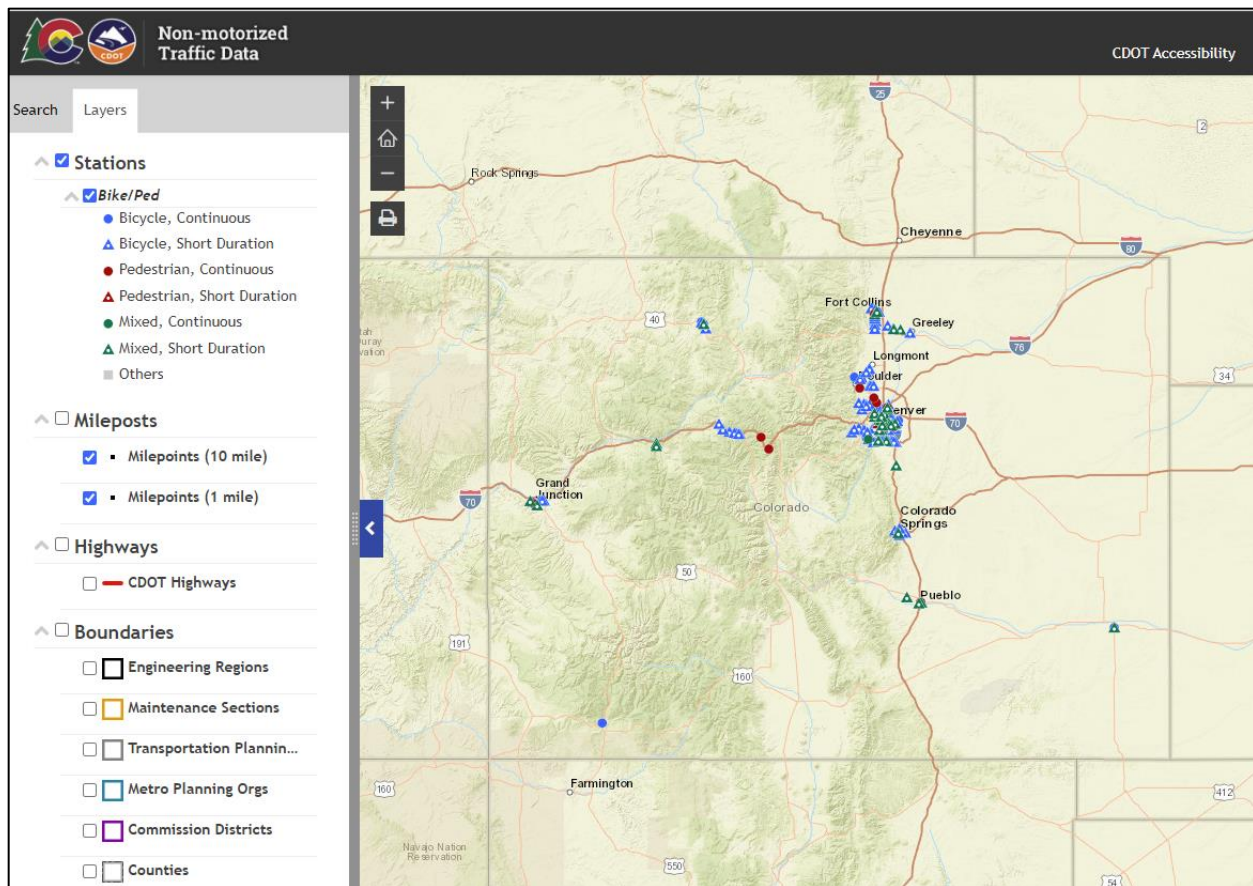


Figure 2.2 CDOT Counter Network for Nonmotorized Traffic Counts
Source: (26)

CDOT uses pneumatic tubes and IR sensors for short-duration counts. Pneumatic tubes are used to count bicycles on trails or roadways. CDOT typically installs tubes at three or four locations along a corridor to facilitate error detection (e.g., over- or undercounting). IR sensors are mostly deployed on trails and sidewalks. Four sensors are rotated throughout the state, and each is typically installed for one month at a location.

2.3.3 Delaware DOT (DeIDOT)

In 2013, DeIDOT established a statewide pedestrian and bicycle data collection program. The program began with short-duration counts using Eco-Counter equipment — including pneumatic tubes and passive infrared detectors — at 10 locations, each for a two-week period. Insights from the pilot informed the count program strategy which includes plans for at least 10 – 15 permanent count installations and 30 short-duration stations. Permanent count stations are identified based on evaluating data from short-duration counts (25). For the statewide count strategy, DeIDOT determined that screen line counts are ideally suited to its program. To monitor bicycle traffic in multiple settings, DeIDOT employs the Eco-Counter Tube system in two configurations: the traditional pneumatic tube (for trails, paths, or other bicycle-only locations) and the mixed-traffic tube (used on-street to distinguish bicycles from motor vehicles) (27).

2.3.4 Florida DOT (FDOT)

FDOT's Transportation Data and Analytics (TDA) Office established a Statewide Non-Motorized Traffic Monitoring Program (NMTMP) to provide bicycle and pedestrian volume counts, supporting statistics, and information to new and existing data customers (28). Data collected through the program can be used for safety studies, planning and programming of FDOT facilities, road and trail maintenance, and enhancements. The agency has created a statewide data repository that stores information on permanent and short-duration counts. One notable feature of the program is the equipment loaner program which allows district offices to collect and submit short duration count data. District-level participation is essential as staff are familiar with local patterns of how cyclists and pedestrians use sidewalks, side paths, and shared-use paths. FDOT has 96 permanent count sites — 83 sites are located on the Shared-Use Nonmotorized (SUN) trail Florida Network (Figure 2.3) (29). Of the 96 permanent count sites, 59 use Eco-Counter Urban multi-devices, and 21 use QFREE EMU3 B/P counters. As part of this program, the City of Tampa obtained a high-visibility, digital unit that uses camera sensors to count passing pedestrians and bicyclists in real time and displays daily totals and annual figures (30).

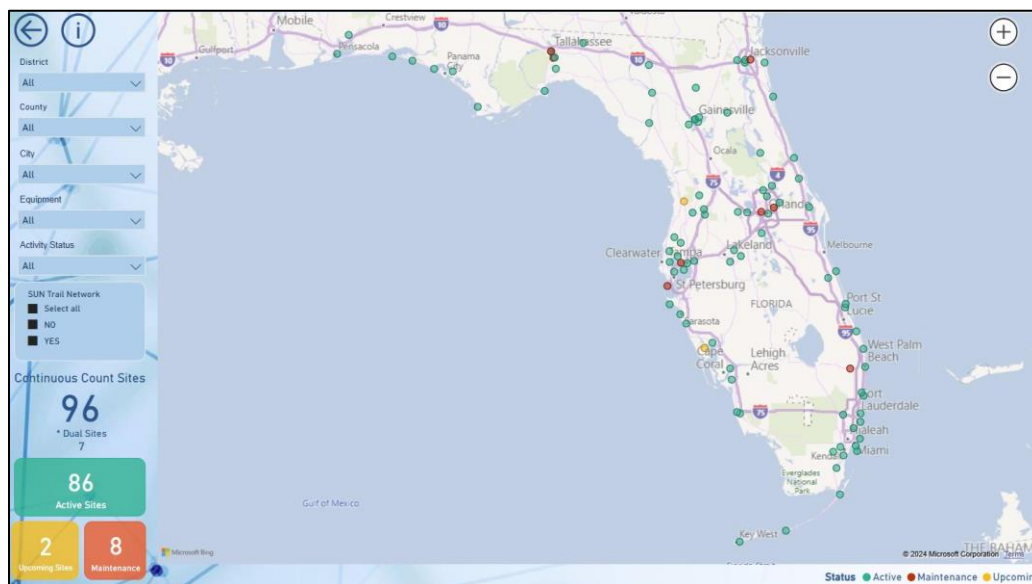


Figure 2.3 Florida Non-Motorized Traffic Monitoring Program — Power BI Report
Source: (29)

2.3.5 Iowa DOT

The Iowa DOT established a statewide bicycle and pedestrian counting program in 2017 to assess crash exposure (31) (32). The program includes 41 counting sites — two permanent count stations and 39 short-duration count stations (Figure 2.4). One-week short-duration counts were conducted between 2017 and 2022, while the permanent count stations have operated since September 2017. The sites represent a range of conditions, including recreational, commuting, and mixed-use environments, as well as urban and rural settings and multiple roadway classifications (local, collector, arterial, and trail). The program uses a combination of PIR sensors and inductive loops.

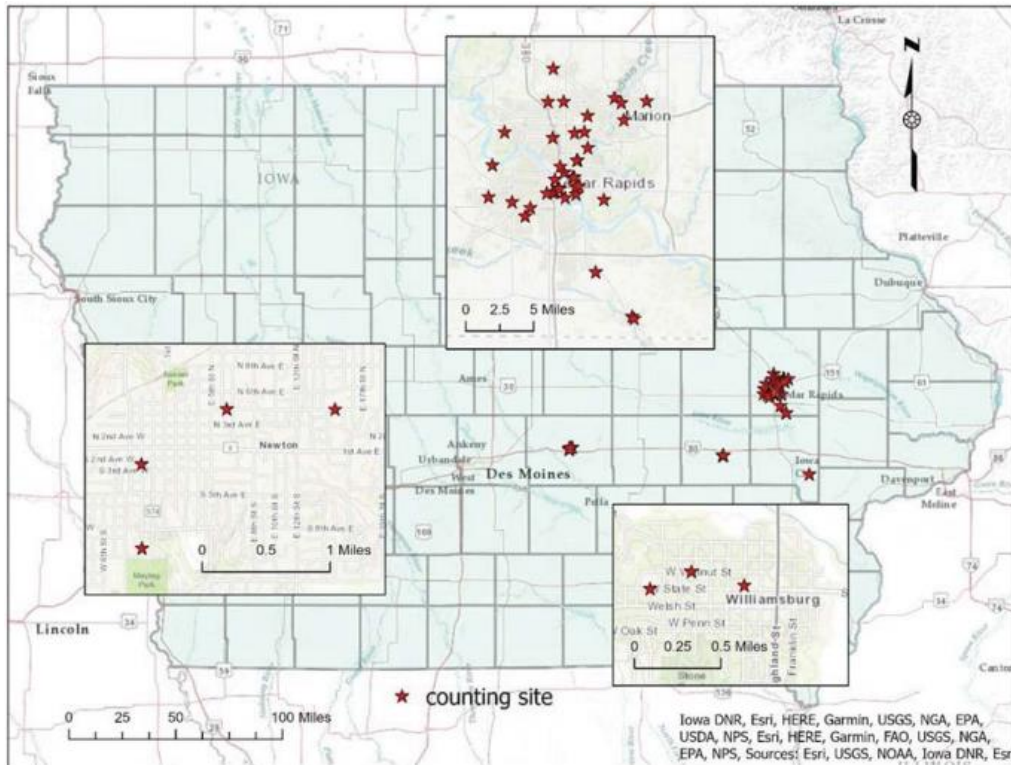


Figure 2.4 IDOT Permanent and Short-Duration Counting Locations

Source: (32)

2.3.6 Michigan DOT (MDOT)

MDOT's Non-Motorized Data Collection and Monitoring Program is "a strategic, coordinated, and efficient approach to collecting and analyzing nonmotorized volume data in Michigan" (33). Local agencies have submitted count data to a centralized statewide database gathered from 20 permanent and 63 short duration counting stations. Permanent count stations have generally been installed in less-populated census tracts. To date, all stations have been placed exclusively on shared-use paths. Installations have IR sensors, inductive loops, or a combination of the two. Despite the number of stations, a significant coverage gap persists due to permanent count stations being installed only on shared-use paths. MDOT has emphasized the need for more stations in areas with medium-to-high population densities (33). Another concern with permanent count stations is the use of IR technology, which cannot distinguish between bicyclists and pedestrians. Concerns over data quality linger because it is unclear whether permanent and short duration count data have been validated, which may degrade accuracy. To ensure volume estimates are representative, the agency recommends stratified random sampling for selecting short duration count locations.

2.3.7 Minnesota DOT (MnDOT)

MnDOT's Minnesota Pedestrian and Bicyclist Data Program established a network of automated counting stations (34) (35). Partner agencies (e.g., cities, counties, MPOs) and NGOs can borrow equipment from MnDOT to conduct automated short-duration counts (36). The program collects nonmotorized traffic data and has developed a methodology for analyzing, validating, evaluating, and managing these data. MnDOT utilizes IR, inductive loops, pneumatic tubes, and radar sensors (Table 2.2). Currently, it has eight portable counter kits, one in each of its eight districts. Each kit includes an Eco-Pyro Box and an Eco-Counter Tube. PIR sensors are used at short-duration portable counting stations. At permanent sites, PIR sensors and inductive loops are used. Twenty-one permanent counts stations (Figure 2.5) are distributed throughout the state.

Table 2.2 Sensors Currently in Used in Minnesota

Counter type	Modes Counted	Installation Difficulty	Agency	Vendor
Inductive loops	Bikes	Difficult	MnDOT	Eco-Counter Eco-Zelt
Multiple technologies	Bikes and peds separately	Difficult	MnDOT, Rails to Trails, and the City of Minneapolis	Eco-Counter Eco-Multi
Pneumatic tubes	Bikes	Intermediate	MnDOT, Hennepin County	TimeMark, MetroCount
In Road sensors	Bikes	Difficult	Hennepin County	Sensys Net-works
Active infrared	Bikes and peds combined	Easy	Minneapolis Park & Recreation Board, ARDC, and DNR	TrailMaster – TM 1550
Passive infrared	Bikes and peds combined	Easy	MnDOT, and DNR	Eco-Counter Eco-Pyro
Radar (Microwave beam)	Bikes and peds separately	Easy	MnDOT	Chambers Electronics

Source: (9)

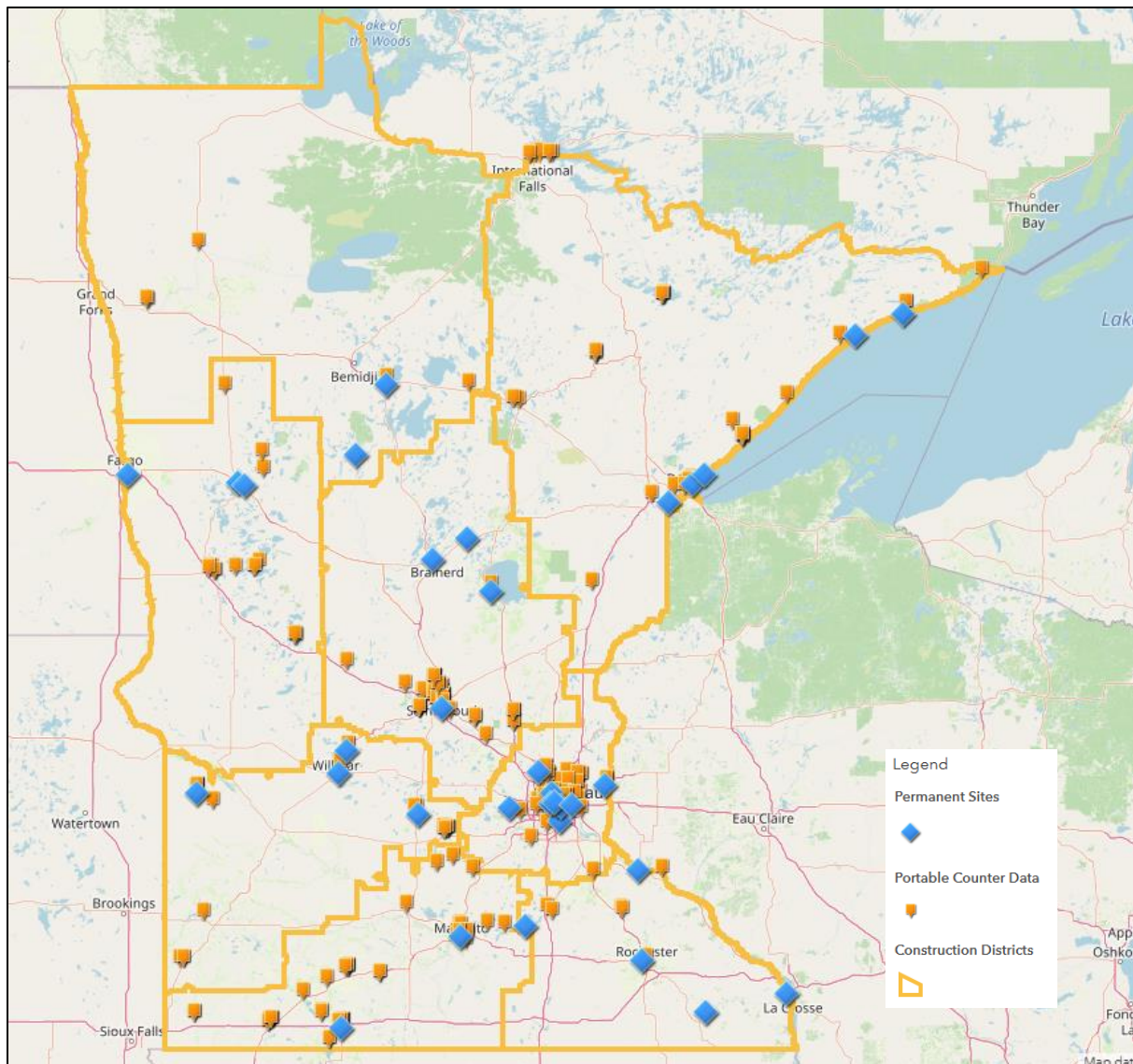


Figure 2.5 Minnesota Bicycle/Pedestrian Counter Sites

Source: (37)

2.3.8 North Carolina DOT (NCDOT)

The Non-Motorized Volume Data Program (NC NMVDP) manages an extensive network of permanent bicycle and pedestrian counting sensors. It provides comprehensive data management and reporting for local agency partners and operates through collaboration between local partners, NCDOT, ITRE, and Eco-Counter (38). The program began as a pilot project in November 2013 in NCDOT Divisions 7 and 9, which had the most complete GIS datasets on nonmotorized facilities (39) (40). Sites are chosen to include multiple facility types — sidewalks for pedestrian detection, shared-use paths, bicycle lanes, and shared lanes with motor vehicles. Pedestrian counts rely on post-mounted PIR sensors, while bicycle counts are collected using inductive loops. These counting systems, called MULTI systems, are manufactured by Eco-Counter.

2.3.9 Texas DOT (TxDOT)

TxDOT collaborates with regional and local agencies to maintain a comprehensive exchange of bicycle and pedestrian counts. In partnership with the Texas A&M Transportation Institute (TTI), TxDOT developed a system that allows entities collecting bicycle or pedestrian count data to import, manage, quality review, factor, and share data. This initiative is spearheaded through the Texas Bicycle and Pedestrian Count Exchange (BP|CX) (41). The program includes 172 permanent count locations and 817 short duration count locations, distributed across multiple facility types (Figure 2.6).

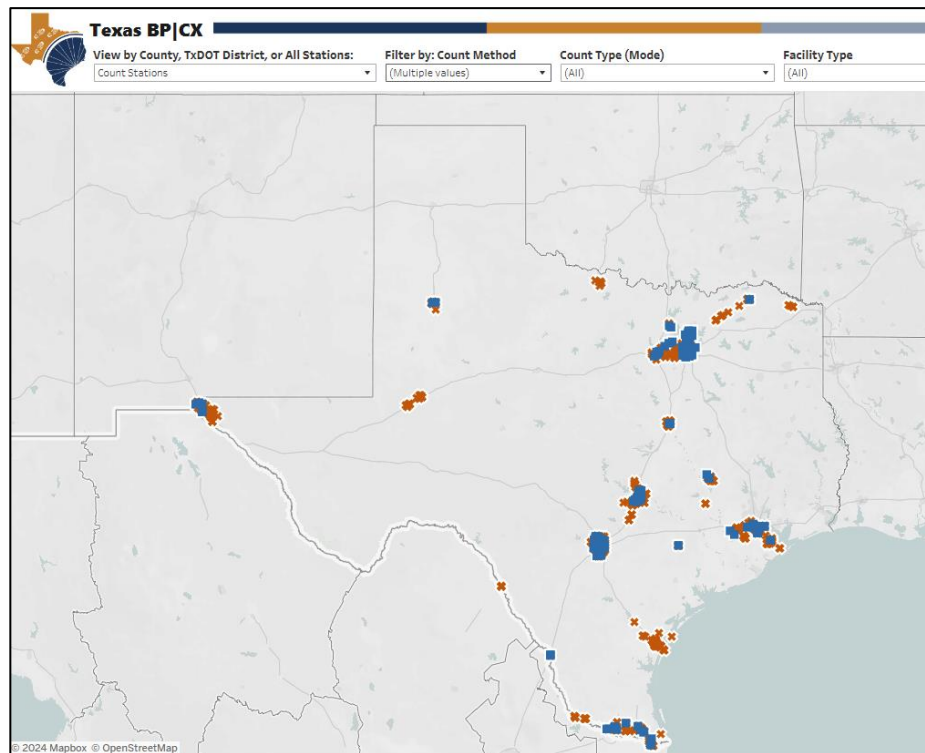


Figure 2.6 Permanent (Blue) and Short-Duration (Orange) Count Sites in Texas
Source: (41)

Permanent count locations collect data year-round, and are categorized into three pattern groups: commuting to work/school routes, recreational/utilitarian routes, and hybrid routes (mix of commuting and recreation). According to TxDOT, the recommended number of locations per traffic pattern group is 30. The TxDOT counter equipment program offers 10 IR counters and 8 pneumatic tube counters for bicycle data collection. Additionally, TxDOT has licensed four years of statewide Strava Metro data (2016 – 2019) to supplement its data with crowdsourced information (42).

2.3.10 Virginia DOT (VDOT)

VDOT maintains 351 counting stations with equipment from Eco-Counter (Figure 2.7) (43). The VDOT Active Transportation Count Program includes permanent and short-duration count stations. The agency also performs year-over-year (YOY) short-duration counts as part of the Statewide Active Transportation Count Program. Counts are conducted periodically at the same locations during the same time of year using automated counting equipment. Despite their limited scope, VDOT's YOY counts provide the most comprehensive on-street bicycle facility use data in Virginia. (44). The agency relies on pneumatic tubes and a combination of IR sensors and inductive loops (45).

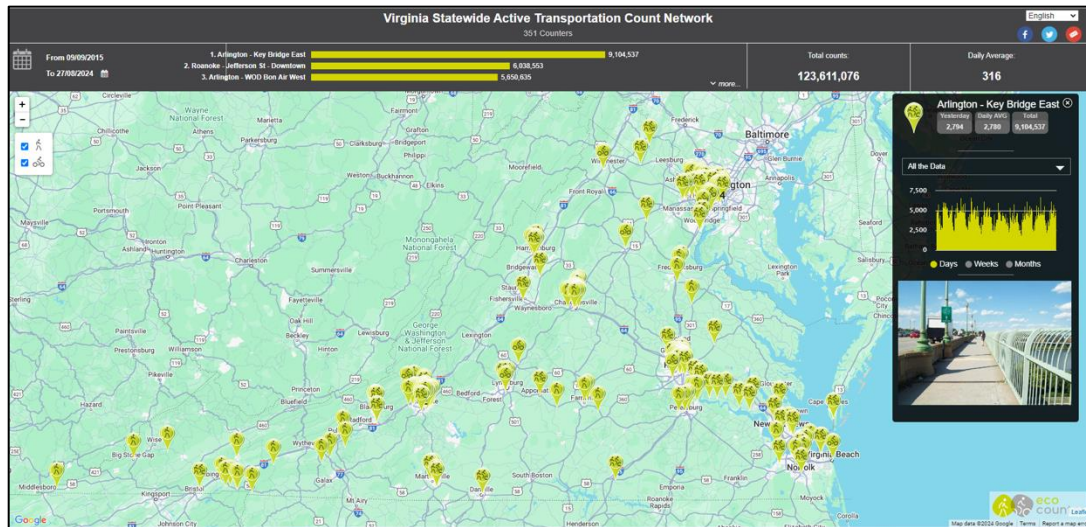


Figure 2.7 Virginia Statewide Active Transportation Count Network
Source: (43)

2.3.11 Washington State DOT (WSDOT)

WSDOT has operated bicycle and pedestrian count programs since 2015 and now collects data at 73 permanent count stations (46). The agency has also managed the Washington Bicycle and Pedestrian Documentation Project since 2008, which conducts manual counts of bicycle and pedestrian usage at urban intersections (47). WSDOT uses Eco-Counter technologies, specifically the Urban MULTI counter, which employs a combination of PIR sensors (PYRO model) and inductive loop (ZELT model) technologies to differentiate pedestrians and bicyclists (48) (49).

2.3.12 Other Local and Regional Efforts

Alameda County, CA

The Alameda County Transportation Commission (Alameda CTC), in collaboration with regional agencies and educational institutions, has collected bicycle and pedestrian data across the county since 2002 (50). Alameda CTC conducts manual counts biennially at 150 locations using the NBPDP methodology (15).

City of Long Beach, CA

For the Long Beach Bicycle and Pedestrian Count, volunteers manually count bicyclists and pedestrians, recording travel behavior such as helmet use and wrong-way riding (51). In 2016, the city installed its first Eco-totem, a device that uses IR and inductive loops to count pedestrians and bicyclists in real time and displays daily and annual totals for each travel mode on a screen. A second Eco-totem was installed in 2019 (52).

City of San Francisco, CA

Since 2006, the San Francisco Municipal Transportation Agency (SFMTA) has conducted annual bicycle counts at intersections (53). The agency monitors bicycle volumes and commute trends using three methods: ACS Commute Data, annual manual bike counts at designated locations, and automated counters deployed throughout the city (54).

Since 2016, the Bay Area Toll Authority (BATA) has maintained a system of permanent count stations on five toll bridges to record trips on select bicycle/pedestrian paths (55). Most equipment can differentiate between bicycles and pedestrians. In 2018 SFMTA adjusted manual count locations to better align with the current bike network.

Figure 2.8 shows locations where manual counts were conducted in 2019 (54). The same year, 75 automated bike counters were installed citywide to collect bike volume data continuously (56) (58).

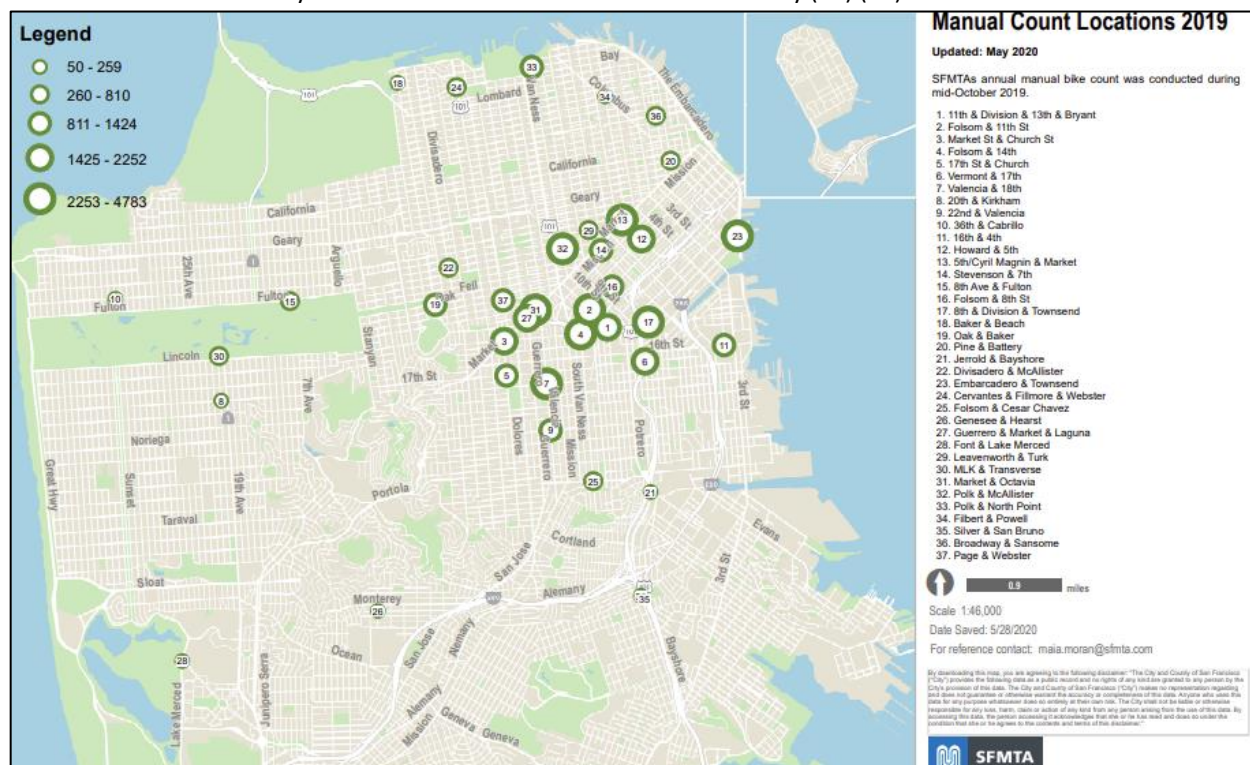


Figure 2.8 Manual Bicycle Count Locations in San Francisco (2019)

Source: (57)

Los Angeles DOT, CA

LADOT conducted its first comprehensive count of nonmotorized users in 2019 using manual counts and video camera observations (59). Video recordings let staff review footage, improving count accuracy (60). Count locations change each year and focus on areas with recent or planned mobility improvement projects. Between 2021 and 2022, LADOT, in collaboration with the Bureau of Street Lighting, installed 35 permanent pedestrian and bike count stations (Figure 2.9). Typically, two stations are placed at each location — one on each side of the street. The city has also installed two display screens at locations with high bicycle ridership.

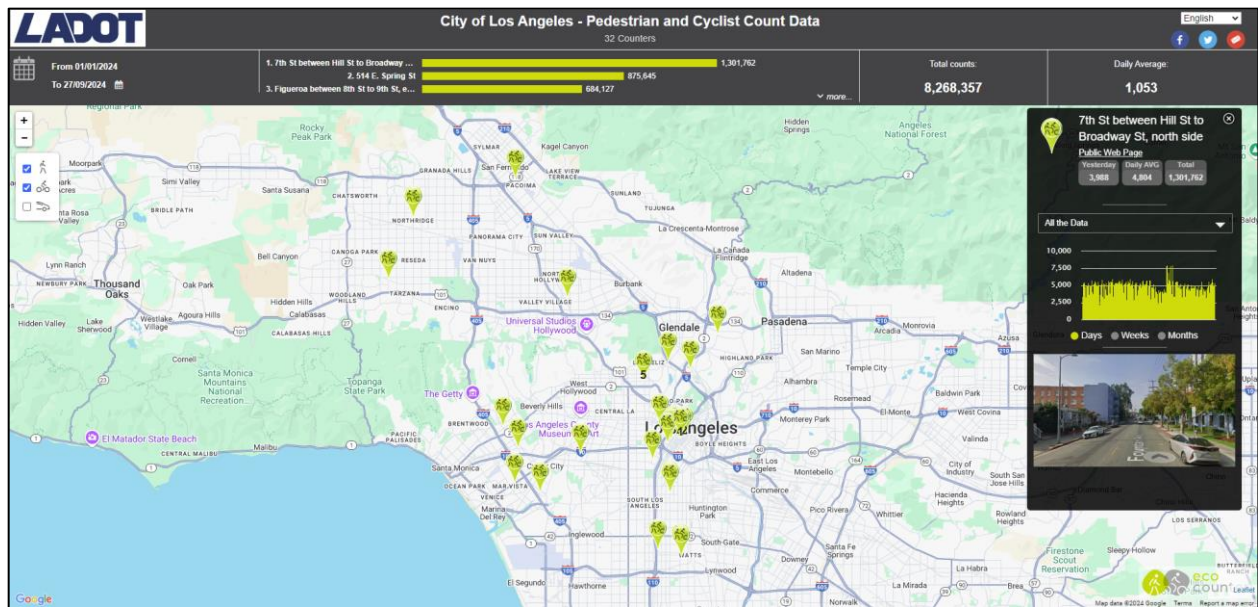


Figure 2.9 City of Los Angeles — Pedestrian and Bicycle Count Data
Source: (62)

LA Lights (61) is piloting non-intrusive pedestrian and mobility equipment manufactured by Eco-Counter. Its software uses an algorithm to recognize pedestrians, cyclists, scooters, and vehicles, transmitting real-time data without recording images. These data help the agency verify lighting levels are adequate during peak traffic periods. Insights from these counters will inform future city infrastructure projects (e.g., smart poles, transitional lighting zones, other safety enhancements).

City and County of Honolulu, HI

Since 2022, the City and County of Honolulu's Department of Transportation Services has installed 38 pedestrians and bicyclist count stations (63). Stations are located along bike lanes and multiuse paths (64). Bicycle counters use inductive loop technology, while pedestrian counters utilize a PIR sensor in a post (65).

Western Maine Region, ME

Since 2019, the Androscoggin Transportation Resource Center (ATRC) has managed a short-duration bicycle and pedestrian count program to assess changes in bicycle traffic volumes and conduct before-and-after studies to evaluate the impacts of infrastructure projects (66). Bicycle counts are conducted at all signalized intersections in the region as part of the vehicle turning movement count program, with additional sites added based on partner requests. The program relies on machine vision and radar counters (45). While the capital costs of machine vision systems are comparable to other automated count technologies, video data require processing through a fee-for-service model provided by the hardware vendor (45).

Town of Cary, NC

In 2012, the Town of Cary installed bicycle and pedestrian counting devices on the town's greenway and bicycle system (67). The counting technology uses a combination of PIR and ZELT inductive loop sensors, which together tally the numbers of runners, bikers, and walkers.

City of Norfolk, VA

The City of Norfolk's Bike-Pedestrian Counter Program collects pedestrian and bicycle data to justify existing infrastructure and support the planning of and investment in future network expansions and safety measures (18). Two types of bike-pedestrian counters are used — PIR sensors and inductive loop sensors.

Bike Walk Richmond, VA

Since 2014, Bike Walk Richmond has conducted manual counts twice a year to monitor pedestrian and bicyclist numbers (68). Data are used to assess the impacts of building protected bicycle infrastructure in the urban environment.

City of Fairfax, VA

The city of Fairfax, VA periodically collects bicycle and pedestrian count data using multiple methods, including automated counters and manual counts (69).

Arlington County, VA

Arlington County operates 32 permanent count stations and six portable short-duration counters (70) (71). Most devices installed on shared-use trails differentiate between bicycles and pedestrians, generating separate totals by mode and direction of travel. Other counters, such as those along on-street bike lanes, only count bicycles and assume a single direction of travel (72).

City of Blacksburg, VA

The Bicycle and Pedestrian Traffic Count Program estimates performance measures for streets and sidewalks using manual counts and automated equipment — the MetroCount MC 5600 Vehicle Classifier System (pneumatic tube counters), Eco-Counter PIR PYRO counters, and Chambers RadioBeam Bicycle-People counters. (73).

Seattle, WA

The Seattle DOT operates 12 bike counters on neighborhood greenways, multiuse trails, at Fremont Bridge, and on SW Spokane Street. Four installations also count pedestrians, and three are permanent stations that upload data daily which are displayed online. Data from the remaining seven counters are uploaded monthly (74).

2.4 Agency Efforts — Summary

Most programs employ a combination of permanent and short duration count stations. PIR sensors and manual counts are most often used for pedestrians, while bicyclists are typically counted with pneumatic tubes, PIR sensors, and inductive loops. Nine of the 11 statewide programs reviewed have adopted hybrid systems to distinguish between pedestrians and cyclists. While Eco-Counter is the most widely used vendor, other companies — TRAFx, MetroCount, and Miovision — are well represented.

Chapter 3 Nonmotorized User Count Program

Drawing on material from the previous chapter, this chapter describes steps KYTC can take to establish a nonmotorized user count program.

3.1 Nonmotorized Traffic Data Collection Overview

Collecting data on nonmotorized users is a complex task and demands multiple tools to accommodate the distinct characteristics of different user groups. Several factors must be considered when selecting equipment, count methodologies, and sites where counts are completed:

- Nonmotorized traffic volumes are influenced significantly by precipitation, temperature, time of day, and season.
- Counts are often done on roadways with lower functional classifications, shared-use paths, and pedestrian facilities.
- The equipment used for nonmotorized and vehicle counts is similar — pneumatic tubes, PIR sensors, video technology, inductive loops, — however, nonmotorized traffic presents unique challenges. Bicycles and pedestrians are more difficult to detect because their travel patterns are less predictable and more variable. Unlike vehicles, nonmotorized users are not confined to fixed lanes or paths, and they often make unpredictable movements (e.g., crossing streets at unmarked locations, riding on sidewalks). Nonmotorized users tend to travel in closely spaced groups, which produces counting errors (i.e., multiple users recorded as one user). This is especially problematic in areas of high activity, where accurate data are crucial for planning purposes.
- Nonmotorized counting technologies are becoming more sophisticated and accurate. The continual evolution of these technologies promises further improvements in data collection, allowing for more effective planning and management of nonmotorized user infrastructure.

3.2 Program Planning

Critical to a successful nonmotorized user count program is defining program objectives, assessing resources used for data collection, and determining the program scope. Program objectives may include (7):

- Measuring fluctuations in nonmotorized user activity relative to baseline levels.
- Documenting changes in activity levels following project implementation.
- Informing the public about trends and patterns in nonmotorized user activities.
- Monitoring variations in activity levels by time of day, day of the week, season, and weather conditions.
- Identifying differences in activity across multiple locations in relation to land uses, facility types, and context-specific expansion factors.
- Evaluating local and systemwide activities to prioritize areas for new pedestrian and bicycle facilities.
- Quantifying exposure as part of the analysis of pedestrian or bicycle crash risks at specific locations.
- Developing models to forecast future pedestrian and bicycle volumes across various community locations.

Resource availability (e.g., funding, staff time, volunteers) must be assessed when determining the extent of a counting program. Existing data collection efforts (e.g., intersection traffic counts) may include nonmotorized volume data, which could be incorporated into the overall program. As such, future counts should focus on areas where no data are available.

3.3 Types of Counts and Locations

Robust counting programs have both permanent and short duration counting stations. Because the travel patterns of nonmotorized users are influenced by climate, geography, and local culture, multiple permanent count stations are needed to monitor activity across multiple spatiotemporal scales. (75). Permanent count stations, which collect data for at least one year, are essential for documenting activity patterns and are used to adjust short duration counts to ensure data are representative of broader trends. They can be used also to extrapolate from short duration counts taken at similar locations, allowing for estimates of unknown values based on established patterns in continuous data.

There are two types of short-duration counts: coverage and project-specific. Coverage counts are conducted repeatedly throughout the year and across multiple years, typically for periods ranging from two hours to two weeks (the recommended duration is seven days). These counts enhance the spatial coverage of a monitoring program by gathering data across a broad geographic area and documenting variations in travel patterns. Without corresponding permanent count stations, short-duration counts cannot be adjusted to accurately reflect annual averages. Project-specific counts are scheduled based on project timelines — before, during, and after project completion — to assess project impacts on nonmotorized user traffic.

Agencies must also determine what count type to use (e.g., screen line, intersection). Screen line counts (i.e., volume or mid-block counts) measure bicyclist and pedestrian traffic volumes passing a designated screen line. They illuminate general usage trends and daily/seasonal variation in traffic. Although these counts are conducted at a specific point, they are sometimes applied to an entire segment to estimate metrics such as pedestrian and bicyclist miles of travel.

Intersection counts (turning movement counts) record volumes at intersections. They capture the travel direction for each approach leg and are particularly useful for safety and operational analyses as they can inform signal timing, intersection design, and collision exposure assessments at high-risk crossings. Intersection counts are generally more complex than screen line counts because multiple approaches have to be monitored simultaneously, often demanding more than one counting station to capture a holistic view of movement patterns.

3.4 Count Site Location Selection

Most agencies choose count sites based on factors such as geography, climate, nonmotorized traffic volume, facility type, level of urbanization, local community interest, convenience, and location suitability for the equipment/methods being used. Because resources are limited, agencies should prioritize potential counting locations based on their alignment with program goals and whether it is tracking general trends, monitoring specific projects, or evaluating changes over time. Typically, agencies follow one of the following approaches to select count locations:

- **Random:** Locations are chosen using random sampling. This method may not always capture key strategic points or be suited for automated equipment. A stratified random approach may be selected to reduce randomness. In this approach, site categories are established based on specific attributes (i.e., land use, proximity to attractions, or traffic patterns), and then locations are randomly selected within each category. In general, the random approach is not recommended as it typically misses strategically important or logistically suitable areas for automated counts.
- **Representative locations:** Locations are chosen to reflect known nonmotorized user activity and capture diverse geographic areas, facility types, and socioeconomic contexts. It balances available resources with spatial

coverage, ensuring sites are (in aggregate) representative of the traffic network. This method is well-suited for short duration counts as it provides a snapshot of typical nonmotorized traffic patterns across different conditions.

- Targeted locations: Locations are selected based on specific objectives (e.g., high-crash areas, infrastructure projects, locations where pedestrians and cyclists converge). These sites are often project-based and may include areas with the highest expected volumes of nonmotorized users. Targeted locations are also chosen to address safety concerns or support before-and-after studies, making them suitable for short-duration and permanent count stations.
- Control locations: Locations are chosen to provide a point of comparison, helping to measure actual project effects by accounting for external factors. Control locations are appropriate for short-duration and permanent count stations.
- Index locations: Locations are selected to represent permanent count sites that are used to illustrate broader trends across a state. While neither fully representative of every roadway nor a statistically random sample, these sites capture key data to detect statewide patterns.

Agencies new to monitoring nonmotorized user traffic should prioritize selecting sites that broadly represent the facility network. Agencies should choose locations with high, medium, and low volumes of nonmotorized users and ensuring coverage across the entire network.

3.4.1 Short-Duration Counting Locations

Agencies just starting to monitor nonmotorized travel benefit from collaborating with key stakeholders to identify and prioritize count locations given the available budget. Discussions can help identify regional facilities for establishing permanent count stations. Count locations should be representative of the facility network and include sites with high, medium, and low volumes of nonmotorized users. The 2016 TMG (76) recommends conducting short-duration counts at locations such as:

- Areas with high pedestrian and bicycle activity (e.g., downtowns, schools, parks)
- Urban, suburban, and rural sites across multiple contexts
- Key corridors for assessing impacts of planned infrastructure improvements
- Sites with historical count data
- Locations where geographical constraints channel traffic (e.g., bridge over a river)
- Areas monitored by other agencies using various methods, including video-based counting
- Pinch points or spots that present operational challenges to bicyclists and pedestrians (which are often targeted for improvement)
- Areas with high crash rates involving bicyclists or pedestrians
- Locations with relatively flat terrain, ensuring consistent travel speeds for cyclists
- Sites that satisfy multiple selection criteria

3.4.2 Permanent Counting Locations

Agencies should consider several factors when deciding where to locate permanent count stations:

- Sites where short-duration counts have been conducted previously

- Locations where traffic is funneled to specific thoroughfares due to geographical constraints (e.g., bridges over rivers)
- Representative areas spanning urban, suburban, and rural settings
- Key corridors that can be utilized to assess the effects of future improvements
- Areas characterized by high traffic volumes and well-established bicycle and pedestrian facilities

Agencies should conduct a short-duration count (at least two weeks) before establishing a permanent count station. Short-duration counts establish a baseline dataset and let agencies evaluate traffic patterns to determine if a site warrants continuous monitoring, (77). Permanent count stations should provide geographically and volumetrically representative samples of areas with low, medium, and high levels of nonmotorized users. After identifying facilities that merit permanent count stations, agencies must determine where to install equipment. Several agencies, including the North Carolina DOT (78) and Arizona DOT (79) have implemented one or more of the strategies described above. Both agencies chooses data collection locations using a mix of random, representative, targeted, and control locations to provide complete coverage of nonmotorized user travel.

Chapter 4 Pilot Counter Evaluation

KYTC installed an Eco-Counter, which is an active infrared device, on the Town Branch Commons Trail, near 165 Midland Ave. in Lexington. Manual counts were also undertaken at this location to document actual trail usage. Manual counts were compared to the Eco-Counter's automated counts. Manual counts captured pedestrians, cyclists, e-scooter riders, and other wheeled users, such as one-wheelers and skateboarders, which the Eco-Counter may not detect accurately.

Manual counts were conducted twice per day (morning and afternoon) over four days — two weekdays and two weekend days to capture variations in usage patterns. Table 4.1 describes weather conditions during count days.

Table 4.1 Count Day Weather Conditions

Date	Day	Weather	
		Morning	Afternoon
June 10	Tuesday	Cloudy; 65°F	Sunny; 80°F
June 11	Wednesday	Sunny; 61-70°F	Sunny; 86°F
June 21	Saturday	Sunny; 75-80°F	Sunny; 90°F
June 22	Sunday	Sunny; 80-88°F	Sunny; 95°F

On each day, observers were stationed at the trail for two hours in the morning and two hours in the evening, for a total of 16 hours of observation. Manual counts categorized users as pedestrians, cyclists, e-scooter riders, and other wheeled users (e.g., one-wheelers, skateboards). Baby strollers were recorded separately and not included in pedestrian or cyclist counts.

In addition to normal pedestrian and bicyclist traffic, data collectors observed five cyclists riding outside the trail, either in the adjacent travel lane or on the opposite sidewalk. A small number of utility vehicles were seen driving on the trail as well. Observers documented several baby strollers, but there is no clear indication whether these influence Eco-Counter readings.

Manual counts offer a finer-grained user classifications than automated counters, which may undercount or misclassify certain user types. Table 4.2 presents daily totals from manual and automated counts as well as their differences (calculated as the number of counts recorded by the Eco-Counter minus the number of counts recorded manually).

Table 4.2 Daily Summary of Total Counts

Date	Day	Total		Difference in Counts	
		Manual	Eco-Counter	Count	Percent
June 10	Tuesday	52	55	3	5.5%
June 11	Wednesday	59	57	-2	-3.5%
June 21	Saturday	53	52	-1	-1.9%
June 22	Sunday	36	37	1	2.7%
Total	-	200	201	1	0.5%

Eco-Counter totals were close to the manual counts, although there were small differences. Across all four days, the Eco-Counter recorded 0.5% more users than manual counts. Table 4.3 presents daily count summaries. For manual counts, the cyclists category includes e-scooters, one-wheelers, and skateboarders but excludes baby strollers.

Table 4.3 Daily Summary of User Counts

Date	Day	Pedestrians				Cyclists			
		Manual	Eco-Counter	Diff	% Diff	Manual	Eco-Counter	Diff	% Diff
June 10	Tuesday	37	40	3	7.5%	15	15	0	0.0%
June 11	Wednesday	39	40	1	2.5%	20	20	0	0.0%
June 21	Saturday	42	40	-2	-5.0%	11	12	1	8.3%
June 22	Sunday	19	21	2	9.5%	17	16	-1	-6.3%
Total	-	137	141	4	2.8%	63	63	0	0.0%

During the four-day observation period, the Eco-Counter overcounted pedestrians by four users, a 2.8% overestimation. Overall cyclist counts from the manual and automated counts matched. However, there were small intraday differences.

This analysis demonstrates the Eco-Counter provides a reliable approximation of total usage, especially for cyclists. But the equipment had some variability in pedestrian counts and exhibited a tendency to misclassify unique mobility modes. Unique mobility modes are counted by the Eco-Counter, however, they are classified as cyclists. Some discrepancies between manual and automated counts may be attributed to observers being recorded by the Eco-Counter but not included in manual counting.

The accuracy of automated counts could be improved by developing adjustment factors or modifying sensor placement. Adjusting installation and maintenance procedures for automated counters is necessary. Pneumatic tubes became unmounted after a few days, indicating the need for either a more secure and permanent installation or more frequent inspection and maintenance to ensure consistent data quality.

Chapter 5 Recommended Implementation Approach

KYTC is using a combination of investments, policies, and guidance (e.g., *Complete Streets, Roads, and Highways Manual*) to expand the range of transportation options available to nonmotorized users. However, because the Cabinet has not yet established a formal pedestrian and bicycle count program, the agency does not have full visibility of how demand for facilities used by nonmotorized users varies statewide. Establishing a methodologically robust counting program will let KYTC collect valuable baseline data on pedestrian, bicycle, and micromobility usage; quantify current and future demand; and target investments in areas where demand for nonmotorized transportation facilities is greatest. Based on findings presented in this report — including the review of agency policies, assessment of equipment used to conduct counts, and Lexington-based pilot study — this chapter recommends steps the Cabinet can take to develop a count program that will help the agency meet its long-term goals for improving transportation facilities nonmotorized users rely upon.

5.1.1 Articulate Count Objectives

The Cabinet must identify and articulate the count program objectives as this will inform where counts are done and the frequency of data collection. This is the cornerstone of the program, since different objectives require a different approach in developing the program. It is assumed that the primary Cabinet objectives include understanding current demand, collecting baseline data on pedestrian and bicycle use, and identifying areas where future facility investments are needed. In addition, the SHIFT program has incorporated a pedestrian and bicycle benefit estimation resulting from new facilities added as part of projects that is based on demand prediction models. These models have been developed using statewide modal share and assumptions based on national trends. The count program could be extremely helpful in calibrating these assumptions and ensuring accurate prediction of demand.

5.1.2 Identify Current Local Count Efforts

The Cabinet needs to systematically identify and catalogue all current efforts developed by local agencies and assess what role they can play in establishing a statewide count program. Count locations should be identified along with devices used to conduct the counts. Historical counts should be compiled in a KYTC database to develop demand models and forecasts. In addition, efforts that may be planned for the near future should be included and possibly coordinated with Cabinet activities.

An effort should be also undertaken to ensure compatibility between the counts local agencies currently collect and KYTC needs. To achieve this, KYTC counters should be installed at the same locations that local agencies collect their counts, and a review of the counts should be undertaken to ensure that the collected data meets KYTC needs. Manual counts at these locations would be also helpful in further ensuring compatibility.

5.1.3 Traffic Counter Procurement

KYTC should procure counters based on current knowledge of best practices. A mix of active infrared devices and pneumatic tubes is adequate to cover initial needs. Active infrared devices distinguish pedestrians from bicyclists and can be used for short- and long-term counts and they can be used to both permanent and temporary locations. The Cabinet should pursue a pilot program to ensure counts are accurate. Finally, emerging technologies such as video or automated data collection should be investigated to ensure KYTC is using the most appropriate and current technologies.

5.1.4 Count Locations

KYTC should complete a study to identify locations for permanent count stations. A good starting point for selecting candidate sites is determining where local agencies have established counting points. These locations are likely to

be areas local agencies have deemed there is current demand and could serve as the foundation of the initial count network. Additional areas identified through consultation with other local agencies or KYTC District Offices should be vetted and included in the plan. Locations where demand may be sufficient to support permanent counts should be identified and targeted for preliminary counts to determine infrastructure development needs. To establish statewide needs for bicycle and pedestrian traffic, random sites can be identified, and short-term counts conducted. These locations can be counted on a rotation basis — akin to vehicle traffic counts — once every three or four years to round out the count network.

It is recommended to install a set of permanent counters at locations that locations identified in collaboration with the Kentuckiana Regional Planning and Development Agency (KIPDA), Ohio-Kentucky-Indiana (OKI) Regional Council of Governments, Lexington-Fayette Urban Council Government (LFUCG), and Bowling Green-Warren County MPO. At least one additional permanent counter can be located at each District as identified by the pedestrian and bicycle coordinator. These counters can be used to develop seasonal and temporal adjustment factors similar to those developed for vehicle counts in Kentucky.

Once projects are identified, short-duration counts should be done to measure existing demand. Upon project completion additional counts should be performed to evaluate the project's impact on attracting pedestrian and bicycle traffic. Control sites should be used to determine if resultant changes in demand are due to the project rather than broader trends.

A set of counters should be used to also validate a sample of the demand models for pedestrian and bicycle traffic as developed for SHIFT. Corridors that currently have such facilities can be identified and temporary counters should be placed for short-term counts, e.g., four to six weeks, to collect the required data. These counts can then be utilized to calibrate the demand models and determine their accuracy in predicting future demand.

5.1.5 Program Evaluation

After 18 months of data collection the count program should be reviewed to determine whether it is helping KYTC address its objectives. Any issues identified by the review should be resolved through corrective action (e.g., modifying the number of count locations, adjusting the frequency and duration of counts, changing equipment, improving equipment maintenance). This review will let the Cabinet address shortcomings of the program. Another activity during this evaluation could be the collection of manual classification data akin to the efforts undertaken in vehicle counts. This effort provide a basis for establishing a classification distribution among users, i.e., bicycles, e-scooters, wheelchairs, etc.

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Appendix A Distribution of Nonmotorized User Counting Programs Across the US

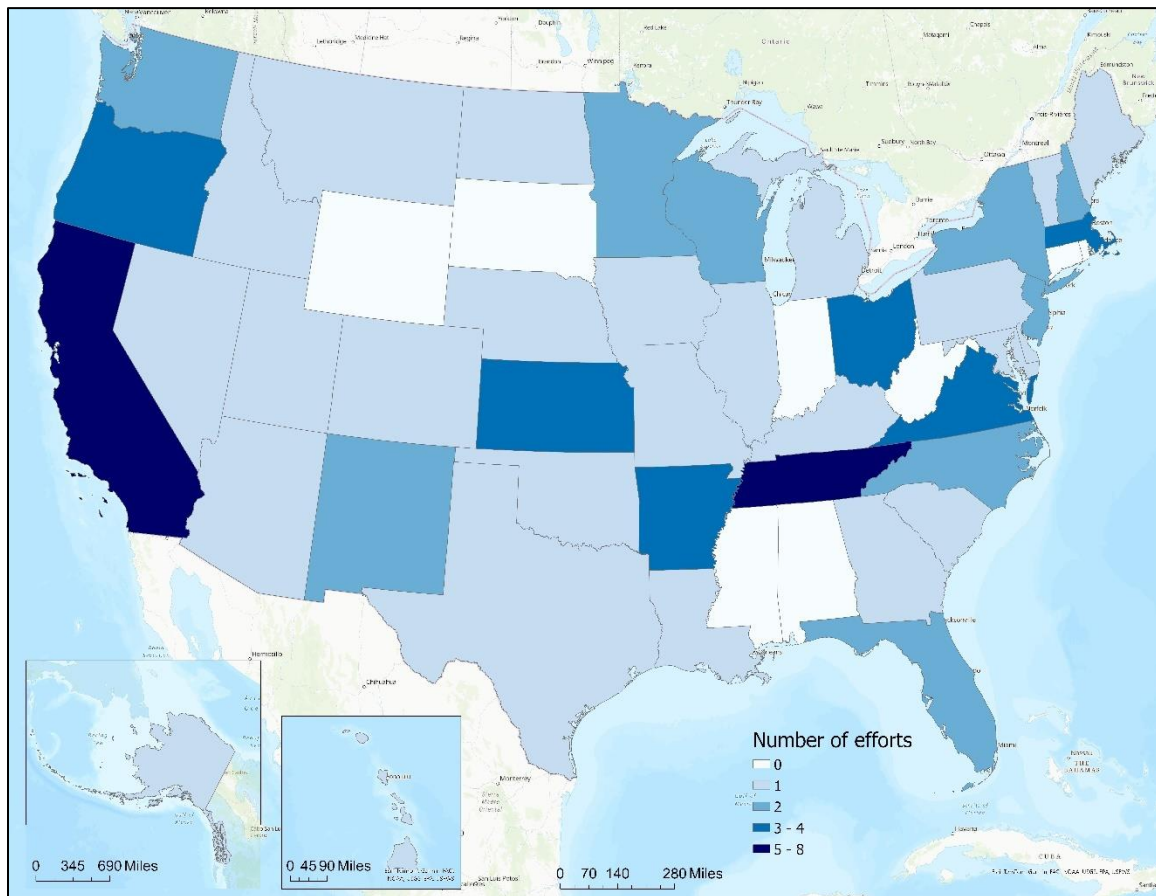


Figure A1 State of the Practice Across the United States

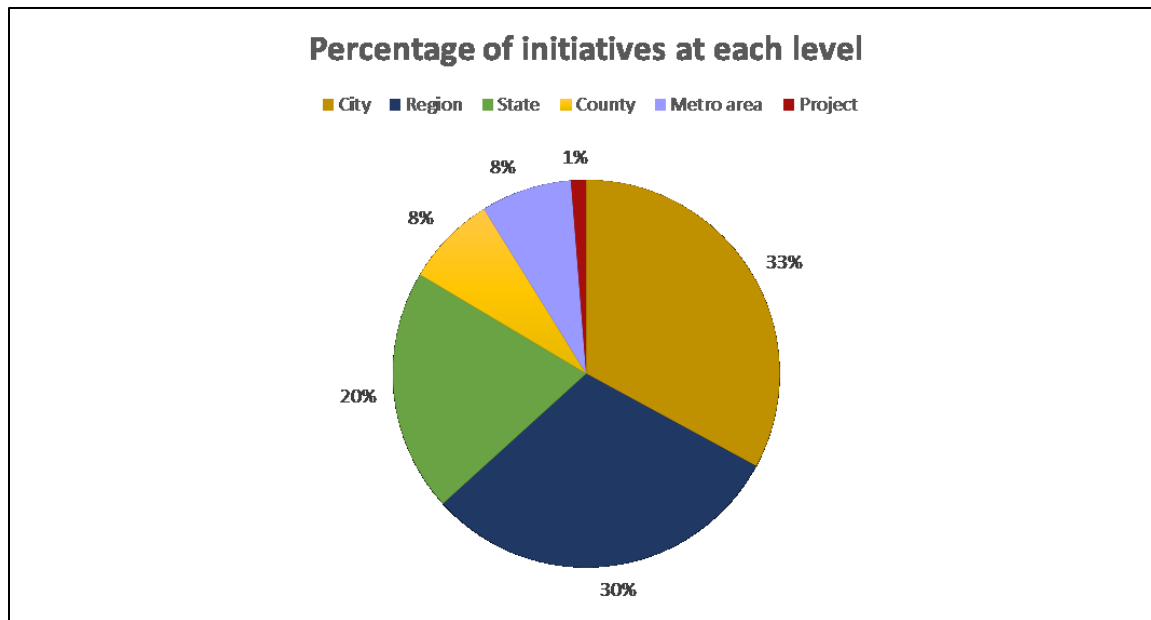


Figure B2 Percentage of Initiatives at Each Level

Appendix B Comprehensive Review of Agency Efforts

An Excel spreadsheet summarizing agency-level efforts can be downloaded from UKnowledge on the same webpage as this report.