Bicycle and Pedestrian Count Programs: Summary of Practice and Key Resources

There is a national interest in quantifying bicycling and walking on roads, paths, and sidewalks. Jurisdictions ranging from cities, states, counties, parks departments, to downtown business districts are turning their focus on better understanding active, nonmotorized transportation. Why? Some want to track change over time to plan, design, and advocate for future accommodation for people who walk and bicycle. Others want to study pedestrian and bicyclist safety to understand exposure to collisions in order to put crash statistics in perspective. Still others want to estimate the economic value of properties or advertising, or the health impact of community-wide physical activity levels, based on the number of people walking or bicycling.

Whatever the purpose, pedestrian and bicycle counts provide the foundation for estimating nonmotorized travel on a path, road, network,

or city level. While foundational count data can be combined with other data such as GPS trace data from smartphone apps, or sociodemographic data from the American Community Survey, this info brief will focus specifically on how to develop and maintain a count program. Without the foundational data from counts, other data sources cannot be validated and adjusted to estimate volumes on roads and paths. There is no substitute for accurate count data.

The purpose of this info brief is to provide a concise summary of current practice and key resources for those interested in starting, expanding or maintaining bicycle and pedestrian count programs. Table 1 summarizes some common reasons for collecting information on pedestrian and bicycle travel volumes and the primary data collection elements needed for each.

Figure 1. Inductive loop bicycle counter combined with passive infrared counter to count pedestrians and bicyclists separately on a path in Arlington, Virginia.

(Source: www.pedbikeimages.org / Krista Nordback)

Figure 2. Inductive loop bicycle counter on road and sidewalk and passive infrared counter on sidewalk counts pedestrians and bicyclists on sidewalk plus bicyclists on the road in Chapel Hill, North Carolina.

(Source: www.pedbikeimages.org / Krista Nordback)

Key terms

Annual Average Daily Nonmotorized Traffic (AADNT): The average daily pedestrian and/or bicyclist traffic crossing a location in both directions over a calendar year.

Continuous counts: Counts of pedestrians and/or bicyclists from automated counting devices that count and record 24 hours/day, 365 days per year, usually in 15-minute or one-hour increments at permanent data collection sites.

Correction factors: These factors adjust the count for consistent under or overcounting. There are many causes of under or overcounting such as equipment accuracy or bypass errors.

Factors: Factors are numbers used to adjust the count up or down due to consistent biases. Two types of factors are discussed in this guide: correction factors and temporal adjustment factors.

Factor group: Collection of count sites that are grouped by a similar travel pattern, facility type, or volume level and mode from which a corresponding temporal adjustment factor is produced (in the case of continuous count site data) or to which the factor is applied (in the case of short duration count site data). Common example factor groups include commute, recreational, and mixed.

Manual counts: Counts collected by human beings (volunteers, staff, or consultants) who record counts in the field or from video transcribed in the office. These counts may be recorded using a clipboard and paper, an electronic counting board, a smartphone app, or a computer spreadsheet.

Temporal adjustment factors: These factors adjust the count to the annual daily average. A temporal adjustment factor of one means that the count already represents an average day. These factors are created from the continuous counters and are applied to short duration counts.

Segment: A section of road or path along which pedestrians and/or bicyclists have little or no opportunities to enter or exit. The segment may be curved or straight, long, or short.

Segment counts: Also known as screenline counts, these are collected when a pedestrian or bicyclist passes an invisible line across a road or path.

Short duration counts: Counts of pedestrians or bicyclists passing through a given location collected over a time period that is substantially less than a year (commonly one hour to one month, with seven days recommended). Short duration counts can be collected manually or by a counting device.

Validation: The process of assessing the accuracy of a counting device.

Primary Pedestrian and Bicycle Traffic Volume Data Elements by Purpose

Purpose	Geographic Level	Primary Data Collection Elements*
Formulate public policy	Area	Travel survey repeated at regular time intervals and permanent continuous counters with additional short duration counts
Measure change over time	Path or road	Permanent continuous counters with additional short duration counts, if needed
	Area	Travel survey repeated at regular time intervals
Prioritize projects	Path or road	**Short duration cyclical counts adjusted with temporal adjustment factors from permanent continuous counters**
Plan and design future facilities	Path or road	
Calibrate regional model	Path or road	
Assess and market commercial real-estate	Path or road	
Identify and assess the value of locations for advertising (billboards, etc.)	Path or road	
Study safety performance	Road	
	Intersection	Turning and crossing movement counts, usually at peak hours; preferably adjusted with temporal adjustment factors from permanent continuous counters
Adjust signal timing	Intersection	Turning movement counts including crosswalks, usually at peak hours
Conduct before/after safety study	Safety counter-measure on road segments or intersection	Special purpose short duration counts, preferably adjusted with temporal adjustment factors from permanent continuous counters
Compare safety performance across cities or regions	Area	Travel survey or diary
Assess community-wide physical activity	Area	

Table 1. Primary Pedestrian and Bicycle Traffic Volume Data Elements by Purpose

Note: "Area" indicates neighborhood, city, or any other population level area beyond a single facility.

* This does not include the many data sources that could supplement these data sources (such as GPS trace data from smartphone apps, or sociodemographic data from the American Community Survey), nor does it include other types of data that would be needed for these purposes such as infrastructure, crash data, or sociodemographic information.

This info brief will not address all of the data elements listed in the table, but instead will focus on the foundational primary elements needed for studies of roads or paths: short duration cyclical counts adjusted with temporal adjustment factors from permanent continuous counters.

The Federal Highway Administration (FHWA) Traffic Monitoring Guide (TMG) (FHWA, 2016) provides direction for designing a count program for this approach, and the National Cooperative Highway Research Program (NCHRP) Report 797 (Ryus et al., 2015a) and its associated web-only documents (Ryus et al., 2015b and Ryus et al., 2017) provide additional details on program design and equipment. This info brief will not duplicate these resources, but instead directs readers to resources by topic and summarizes best practice based on the experiences of multiple national and state count programs, including the exemplary program conducted by the Delaware Valley Regional Planning Commission (DVRPC).

Figure 3. Installation of pedestrian and bicycle continuous count site on South Tryon St. bridge, Charlotte, North Carolina. The bridge is a funneling point that provides access to the city center for people who would otherwise have no way to cross the freeway below it.

(Source: Institute for Transportation Research and Education (ITRE), North Carolina State University)

As explained in the TMG, pedestrian and bicycle count programs have two essential elements: continuous permanent counts, which record travel patterns over time; and short duration counts, which record spatial distribution of travel. Important aspects of count programs include:

Site Selection

- inventory
- continuous counter site selection
- short duration count site selection
- system expansion

Short Duration Counts

Example

The Delaware Valley Regional Planning Commission (DVRPC), uses permanent and short duration automated counters to collect bicycle and pedestrian volumes at a variety of locations. The region has developed an integrated publicly available database to store, analyze, and share results from the counting program. DVRPC is also using day-of-year temporal adjustment factors from permanent counters to estimate annual average daily bicycle and pedestrian traffic at week-long count sites.

Equipment

- selection
- installation
- validation
- maintenance

Data Management

- quality checking
- site grouping
- temporal adjustment factor creation
- applying temporal adjustment factors
- data sharing
- reporting

Each of these will be discussed briefly, with references to other helpful resources.

Site Selection

Inventory

The first step in creating or improving a count program is identifying existing data. What types of counts are already being collected, where, and when? Identify which sites are short duration count sites and where continuous counters are located. Are the data accurate? For permanent counters, even a basic graph of counts by day over the entire duration of data collection can reveal problems.

Continuous counter site selection

Much guidance is available on this topic (O'Brien et al., 2016; Johnstone et al., 2017) yet selecting the right site is a critical and often time-consuming part of the process. Consider equipment-specific siting criteria, travel pattern, and nonmotorized traffic volume. Consideration of pinch points in nonmotorized traffic where cyclists and pedestrians must pass under or over a linear obstacle (river, highway, railroad, etc.) will help identify sites with sufficient volumes and may be more representative of travel beyond a small area. If counts are on a roadway with heavy motor vehicle traffic, consider counting sidewalk riders if these are common.

Short duration count site selection

Short duration counts can be either cyclical or for special purposes. This info brief focuses on cyclical counts. Selecting sites for cyclical counts should include a representative sample of road or path segments using spatial variables that impact bicycle and pedestrian traffic volume as sampling strata. For example, road or path segments may be stratified by region, sociodemographic characteristics, such as population or employment density, or other spatial characteristics, such as proximity to universities or downtown areas. Once the sampling strata are identified, short duration count sites can be identified in various ways depending on the size of each strata, the desired precision of volume estimates on the network, and the resources of the agency collecting the counts. While it would be best to sample all the road and path segments in the study area, this is usually only practical in small study areas. For larger study areas there are two common approaches to count site selection within each strata: by random selection from all road and path segments in each sampling strata (Davis & Wicklatz, 2001) or by specific manual selection from sites identified by agency staff and others including knowledgeable nonprofit organizations (O'Brien et al., 2016; Brady, 2018). Specific manual selection is more representative when sites are selected for high, medium, and low expected nonmotorized traffic volumes as well as a range of facility types and spatial characteristics.

Figure 4. Pneumatic tube bicycle counter used as a permanent continuous counter on the Hawthorne Bridge in Portland, Oregon. (Source: Krista Nordback)

Example

Portland, Oregon installed its first permanent counter on a high bicycle-traffic bridge over a river connecting downtown to the rest of the city. This is a good example of a pinch point counter installation.

Random Selection

An early study of the Minneapolis area sampled by county and road type (Davis & Wicklatz, 2001) used a stratified random sampling approach.

System expansion

Are there enough continuous counters? The third and fourth chapters of TMG provide specific guidance on this subject; Chapter 4 recommends three to five counters per factor group. Recent research shows that at least four counters per factor group are needed for bicycles and five or more counters for pedestrians (Nordback, 2018). If a jurisdiction has the budget and staff to maintain them, using more than eight counters per group is encouraged to further improve accuracy.

Jurisdictions should not install more equipment than they can maintain. Inaccurate or poorly functioning continuous counters cannot produce useful data despite the quantity.

For short duration counters, ensure a representative sample of the road or path segments in each sampling strata (described below). Add additional count sites to the rotation to either sample the entire strata or at least 30 sites per strata.

Short Duration Counts

Most research recommends seven continuous days of counts if estimates of AADNT are needed and automated counting equipment can be used. If weekday traffic count is a focus, 24-hour counts on a Tuesday, Wednesday or Thursday are recommended. Do not count on holidays or holiday weeks as they are not usually representative of average travel at the site. It is best to conduct counts in higher nonmotorized travel months, especially in places with extreme weather differences between seasons.

If automated equipment is not available nor trusted to produce accurate counts in the site conditions (such as shared lanes with high motor vehicle traffic), counts using video or staff in the field can be used. Counts collected from video is preferred as they can be collected (counted in the office or using video image recognition software) for a full 24-hour time period midnight to midnight. If video data collection is not an option due to budget or other considerations, field staff or volunteers can collect counts for up to two hours at a time. Common times are 4-6PM or 5-7PM (Alta Planning and Design & the Institute of Transportation Engineers, 2009). In order to use manual counts to establish travel patterns at a given site, the following was recommended in a Washington State Department of Transportation (WSDOT) study: hours (7-9AM, 11AM-1PM, 4-6PM Tuesday Wednesday or Thursday and 12-2PM Saturday) (Nordback et al., 2017).

Equipment

Selection

Selecting the best equipment for specific conditions and needs of a given jurisdiction is an important decision. Consider ease of installation and maintenance, cost, and data management. Many jurisdictions prefer to select one manufacturer for all equipment to simplify staff training, maintenance, and data management tasks. If staff is already comfortable with a given technology, consider this when choosing counting equipment. Substantial equipment testing was conducted as part of a NCHRP project, so refer to these three reports for information on accuracy by technology type (Ryus et al., 2017; Ryus et al., 2015a and b). This applies to both continuous and short duration counting equipment. In addition, new approaches to bicycle and pedestrian counting are expected as new technology continues to be developed.

Installation

Generally, bicycle and pedestrian counting equipment is more sensitive to installation details than similar equipment for motor vehicle counting. For this reason, it is good for even highly-experienced staff or contractors to take any equipment-specific training offered by manufacturers and carefully read the installation guide. If there are any questions during installation, contact the manufacturer immediately during installation to prevent costly mistakes. If possible, prior to the installation of a new type of equipment, talk to other operators to better understand the process.

Validation

It is highly important to validate equipment. For continuous counters, validate counting equipment about a week after installation. The North Carolina Department of Transportation (NCDOT) provides recommendations for a robust validation process involving one weekday and one weekend day of at least 12 hours per day per site of video data processed (O'Brien et al., 2016) which should be repeated annually or when equipment settings or other physical properties of the count site change

to ensure count accuracy. Data from this validation process can be used to compute a correction factor to adjust data from the site to better represent actual nonmotorized traffic volumes (Ryus et al., Section 3.3.9, 2015a).

Short duration counting equipment should also be validated after purchase, but it is not necessary to perform the robust validation process for every installation. Instead a validation of about 10 pedestrians and cyclists or a 15-minute manual count compared to the device count is recommended.

Maintenance

Monitoring data from continuous counting equipment at least monthly, or weekly or daily for automated data uploads, is highly recommended. This will help identify problems before too much data are lost. Malfunction due to vandalism, insect or other animal activity, or mechanical problems is known to occur. North Carolina State University estimates that it costs roughly 300 dollars per year per counter for proper counter maintenance, plus battery costs and fees for automated data transfer (Carter et al., 2018).

Time	Day of Week	Date	Month	Day Type	B_CHL_MLK	B_CRB_OLD	B_GSO_ELM	B_GSO_SPR	B_GSO_WAL	B_W-S_4TH	B_W-S_END
19	Wed	2015_03_04	Mar	WKDY	5	5	0	8	6	11	3
20	Wed	2015_03_04	Mar	WKDY	2	4	3	9	1	2	1
21	Wed	2015_03_04	Mar	WKDY	2	1	0	3	1	0	0
22	Wed	2015_03_04	Mar	WKDY	4	2	0	1	0	0	0
23	Wed	2015_03_04	Mar	WKDY	3	0	1	3	0	2	1
0	Thu	2015_03_05	Mar	WKDY	1	0		1	2	0	0
1	Thu	2015_03_05	Mar	WKDY	0	0		1	0	1	0
2	Thu	2015_03_05	Mar	WKDY	0	0		2	0	1	1
3	Thu	2015_03_05	Mar	WKDY	0	0		1	0	1	0
4	Thu	2015_03_05	Mar	WKDY	1	0		1	0	0	1
5	Thu	2015_03_05	Mar	WKDY	0	0		1	0	1	0
6	Thu	2015_03_05	Mar	WKDY	3	1		1	0	0	1

Figure 5. Example of raw data showing missing bicycle data from the Elm St. station in Greensboro, North Carolina. North Carolina Department of Transportation's protocol requires that the entire 24-hour day of data be removed from a dataset if four or more consecutive one-hour intervals of counts are missing. Missing data is likely due to a malfunction with the count equipment. (Source: Adapted from O'Brien et al., 2016)
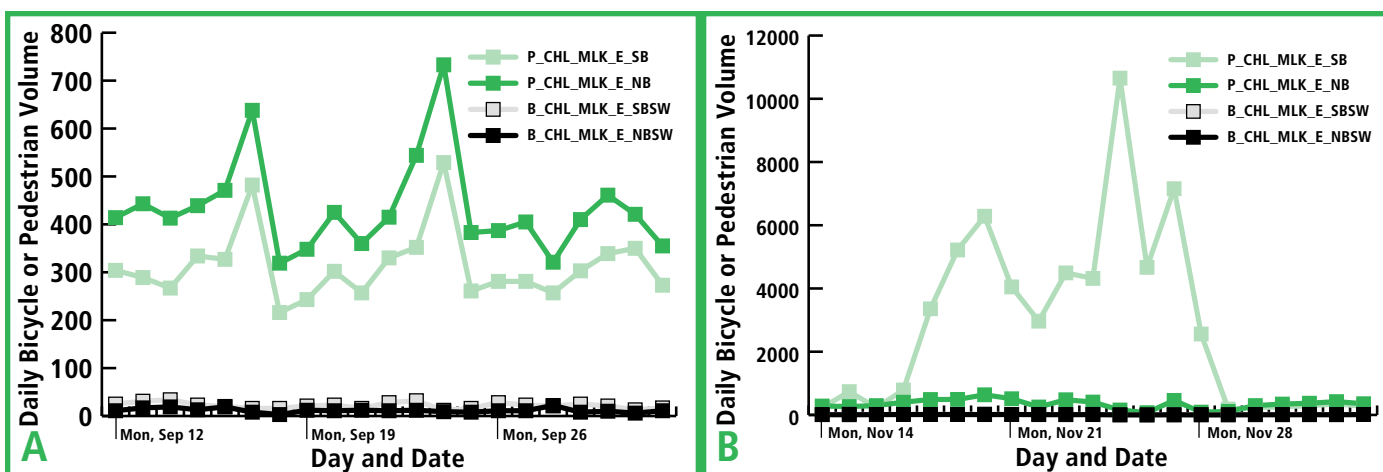
Data Management

Choosing a data management systems depends on agency goals, resources, staff skills, and the quantity and types of data to be managed. Agencies with small data collection programs often use spreadsheets, while larger agencies with multiple data types, such as Colorado Department of Transportation, hire transportation monitoring specific software vendors to manage motor vehicle and nonmotorized traffic data. In addition, some counting equipment manufacturers supply data management software. Some agencies manage their own databases (for example, SCAG, WSDOT and DVRPC). The FHWA has opened its Traffic Monitoring and Analysis System (TMAS) as a data archive and reporting system that any agency can use. Below are some elements of data management to consider.

Quality checking

Monitoring the quality of continuous count data can be conducted manually by visual inspection and automatically by identifying unexpected high counts, long series of zeros or missing data, or sudden increases or decreases relative to past counts at the site. Identifying erroneous data is particularly challenging at low volume sites for which strings of zeros may in fact be accurate and for which there is high variability. Documenting reasons for the very high or very low counts (snow storm, construction, festivals, etc.) in a comments field in the database can be helpful. A FHWA report summarizes common quality checks for continuous counts (Nordback et al., 2016), and a recent scholarship from the Industrial Heartland Trails Coalition and Rails to Trails Conservancy demonstrates the utility of quality checks (Lindsey et al., 2018). In addition, a study by Beitel, McNee, and Miranda-Moreno (2017) discusses how to assess the quality of short duration counts. Figures 5 and 6 show examples of data quality checking.

Figure 6. Examples of (a) good data and (b) erroneous data, caused by an equipment failure, from different time periods from the same permanent counter, shown in Figure 2. (Source: Institute for Transportation Research and Education (ITRE), North Carolina State University)

Site grouping

Several academic studies have focused on continuous count sites grouped by travel pattern for the purposes of creating robust temporal adjustment factors. Some are referenced in this info brief (Miranda-Moreno et al., 2013; Beitel & Miranda-Moreno, 2016). Strategies range from manual visual inspection of travel pattern by day and week to statistical cluster analysis. The goal is to group continuous and short duration sites with similar travel patterns, but this is complicated by lack of data for the short duration sites. First, continuous counters are grouped to create temporal adjustment factors. Then, the short duration counters are also assigned to these groups. For example, if the continuous counters have been grouped into commute, recreational and mixed travel pattern groups, each short duration count site must also be assigned to one of these groups.

Thus, the temporal adjustment factors from the continuous count sites can be applied to the short duration count sites. Strategies include grouping rural and urban sites separately and grouping sites with similar geographic characteristics (for example, proximity to university, school, or downtown area) or type of facility (for example, arterial road or shared-use path in a park). If a full week of short duration counts is available, short duration sites can be accurately grouped by

both weekday patterns and patterns across the week. A Weekend/Weekday Index and Morning Midday Index (Miranda-Moreno et al., 2013) help automate the grouping process.

Temporal adjustment factor creation

After continuous count sites have been grouped, temporal adjustment factors can be created with a sufficiently complete set of continuous count data. If a full 365 days of counts are available or can be reliably estimated for the continuous count sites, research supports using day-of-year factors (El Esawey, 2016; Hankey et al., 2014; Nosal et al., 2014). Day-of-week-of-month factors or month-of-year and day-of-week factors can be calculated if counts from at least one of each day of the week for each month are available (FHWA, 2016).

Applying temporal adjustment factors

Counts from short duration sites are multiplied (or divided) by the temporal adjustment factor to obtain the AADNT estimate. It is important to use temporal adjustment factors from the geographic and climatic region and for the travel pattern that matches the short duration count. Because weather varies from year to year, it is also important to use temporal adjustment factors developed for the specific year in which the short duration count was collected. NCHRP Report 797 details how this process can work (Ryus et al., 2015).

Data sharing

To respond to data requests and to better share data with partner organizations, many jurisdictions share bicycle and pedestrian count data through a public or password protected webpage. Examples of publicly available data include those hosted by DVRPC and WSDOT.

Reporting

Adding bicycle and pedestrian counts to an existing database (such as a motor vehicle traffic monitoring database) can ease reporting. Alternatively, some equipment vendors provide software that produce standard reports from automated data. Manual count data is often managed in spreadsheets and often in a different format than automated count data, which can make managing both types in the same database challenging. Portland State University's Bike-Ped Portal offers a database schema that supports managing continuous and short duration counts (Nordback et al., 2015). FHWA accepts nonmotorized traffic counts into TMAS, which has data export and reporting capabilities. Data submitted to TMAS must be in the 2016 TMG format (Laustsen et al., 2016).

Conclusion

While many data types can give information about walking and cycling in a community, including travel surveys, GPS trace data from smartphone apps, and data from bike share programs, none of these sources can replace the road and path use information provided by counts. They provide a foundational truth for other biased data sources because they count all users. Because it is not possible to employ count methods at every location, it is increasingly important to use count data in coordination with other datasets to estimate bicycling and walking levels at non-count locations and understand factors that influence cycling and walking. As other data sources become increasingly available, such as cell phone data, and technologies become accurate methods for counting, it is expected that estimates of bicycling and walking will improve and become more widely used.

References and Resources

The intention of this info brief is to summarize existing resources rather than to provide comprehensive guidance. With that in mind, below is a list of resources.

NATIONAL GUIDES

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Figure 7. Bicycle counts from a permanent piezoelectric bicycle counter (combined with passive infrared pedestrian and bicycle counter) being validated using a pneumatic tube counter on a shared use path in Portland, Oregon.
(Source: www.pedbikeimages.org/Krista Nordback)

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