

Darlene Wolnik, Farmers
Market Coalition

February 2021

Nony Dutton, FRESHFARM

Jeffrey O'Hara, USDA-
Agricultural Marketing Service

➔ ISSUE

Historically, farmers market managers find it valuable to count their customers at markets, for a variety of reasons. The coronavirus (COVID-19) has added to the importance placed upon the collection of this data. Customer counts may be particularly important in urban farmers market settings where foot-traffic can result in high numbers of visitors, and where the number of visitors can potentially fluctuate drastically. Prior to the COVID-19 pandemic, market managers relied on manual counting methods. While this method has low up-front costs, it is labor-intensive.

➔ INNOVATION

During 2020, FRESHFARM, an organization that manages farmers markets in the Washington, D.C., area, piloted a relatively low-cost device that counts the number of pings from mobile phones as they connect with a Wi-Fi network. This technology does not reveal any of the phone owner's identifying information, nor does it collect data from phones. Instead, these counts provide a way for farmers market managers to estimate the number of visitors and their length of stay at the market. With this technology, managers do not need to expend effort while the market is open to collect this information. The devices are small, light, and require only a credit-card sized Raspberry Pi computer, USB adapter, battery pack, and thumb drive (see Figure 1).

➔ OUTCOME

FRESHFARM successfully piloted this technology at several of its markets in the Washington, D.C., area. Further, the Farmers Market Coalition staff plans on working with partners to pilot these devices in 2021 at farmers markets in Michigan and Mississippi. The devices are still being developed and tested. However, they appear to provide promising support to farmers market operators, especially those market sites with a more complex layout or higher attendance.



Estimating Farmers Market Visitors by Counting Mobile Phone Pings

How is Visitor Count Data Used?

Visitor count data provides farmers market managers with useful information that can be used to improve market operations. Data on visitor density can help managers design the optimal layout for their market. It can also be an input for market-level calculations. For instance, if a market manager had an estimate of the average level of expenditures by visitors, they could estimate the market's aggregate sales by multiplying the number of visitors by average expenditure levels. Further, accurate attendance calculations are data that markets are assumed to have and their stakeholders would like to use. These visitor counts can demonstrate to local officials the importance of the market to surrounding businesses.

During the COVID-19 pandemic, visitor counts can help public health officials determine whether markets are adhering to social distancing protocols that could prevent the spread of COVID-19. An accurate technique for counting visitors could help managers assure policymakers of a reliable estimate of crowd size if they were to change from a market with single point-of-entry to a market with multiple entry points. Also, if the ping counters are placed at strategic locations outside of farmers markets with single point-of-entry systems, they could help market managers estimate whether there are people standing in line that do not enter the market due to the wait, which can lead to a loss in sales.



While visitor counts are helpful to market managers, they face obstacles when estimating crowd size, including:

- Visitors' entry can occur from any direction and visitors are mobile once inside
- Ebbs and flows of visitors within and across market days
- Length of time visitors spend at the market varies
- Some visitors may leave and re-enter a market multiple times in a day

Manual Counting Methods

The simplest manual counting technique, the “walkthrough” method, requires a market manager to walk around a pre-defined route at the market with a handheld clicker and count the number of visitors at the market during a particular interval (Donovan and Kinney, 2016). One drawback of this method is that a manager has to guess the average length of stay for visitors in order to extrapolate these counts to the daily market attendance level, which is difficult to do accurately (Wolnik, 2017). Also, since visitors do not remain in one place in the market while the count is occurring, it is easy to both double-count visitors and miss them altogether with this method.

A more accurate, but also more labor-intensive, system is to simultaneously assign people to each market entry point and count the number of entrants (Lev, Brewer, and Stephenson, 2008). The most accurate approach is to have people allocated to these stations throughout the entire market day (Wolnik, 2017). A less demanding alternative is to have people stationed in those areas at set times on the hour and undertake counts at the stations for ten or twenty-minute intervals.

Even in the latter instance, the number of people required is high for markets with multiple entry points, and this practice may only be feasible several times a year (Wolnik, 2017). Also, since entry points

are typically not formally established for markets, human error in counting is still likely. Using cameras is yet another possibility, although this practice is not widespread among farmers markets (Wolnik, 2017).

Counting Cell Phone Pings

Brick-and-mortar retailers have phone tracking technology to follow customers in their store. Historically, this technology has been cost-prohibitive to farmers markets managers. To rectify this issue, FRESHFARM, an organization that manages markets in the Washington, D.C., area, has been developing a low-cost phone tracking device for market managers to count visitors since 2017 (Wolnik, 2017).

The objective of counting cell phone pings is for market managers to obtain an estimate of the total number of their visitors at their market and the average length of their visit. Cell phones with Wi-Fi capability emit ‘probe requests’ every few seconds as a signal to connect with nearby networks. Each request has a randomized unique identification number. These probe requests are untraceable and do not reveal any identifying information about the user. The random identification number associated with each phone changes daily.

Cell Phone Ping Data

Figure 2 provides a hypothetical visual representation of the data that cell ping counters provide. The figure display, at two-minute frequencies, the number of visitors at the farmers market throughout the day. This hypothetical market opened at 8:30 AM and closed at 9:45 AM. In this example, the number of visitors increases quickly within the first ten minutes of the market and decreases quickly near the end. However, the number of visitors is fairly constant in these figures, which indicates that attendance was well-balanced on this hypothetical market day.

This data can be “filtered” so that it only captures the number of visitors inside the market for a specified duration of time. Filtering the data screens out people that are quickly passing through the market, or on the market perimeter, that may not be shoppers. Farmers market managers can select filter duration based on their institutional knowledge of what they deem is most appropriate and useful for their own market. Figure 2 illustrates the total number of unique visitors at the market for at least five minutes throughout the day. The vertical axis indicates that there were between 70 and 75 unique visitors at any point in time for most of the time at market.

To summarize, these figures provide examples of the data that market managers could analyze. The specific market-level measurement strategies, such as where to locate a device or ways to filter the data, may vary. Still, the device provides managers with a way to estimate the number of visitors that they can integrate into market-level programming.

To summarize, this figure provides examples of the data that market managers could analyze. The specific market-level measurement strategies, such as where to locate a device or ways to filter the data, may vary. Still, the device provides managers

FRESHFARM constructed an affordable do-it-yourself device that can count the number of cell phone pings inside a market. The general cost of components for the device is approximately \$300, which may be cost-effective for markets with heavy foot-traffic. The components of this technology are:

- a Raspberry Pi computer that counts the pings, which is protected inside a waterproof case
- a USB Wi-Fi adapter
- a rechargeable battery
- a USB thumb drive

The Farmers Market Coalition is experimenting with leaving the device inside a simple cardboard box or a plastic tote while at market to reduce any anxieties that shoppers may have if they notice the device. A picture of such a device appears in Figure 1.

The objective of this brief is to provide a conceptual overview of the technology. Each market has its own traffic patterns, and therefore an automated counting system needs to be calibrated for each market. We intend to subsequently develop a short user’s manual for farmers market managers describing how to implement these devices on their own.

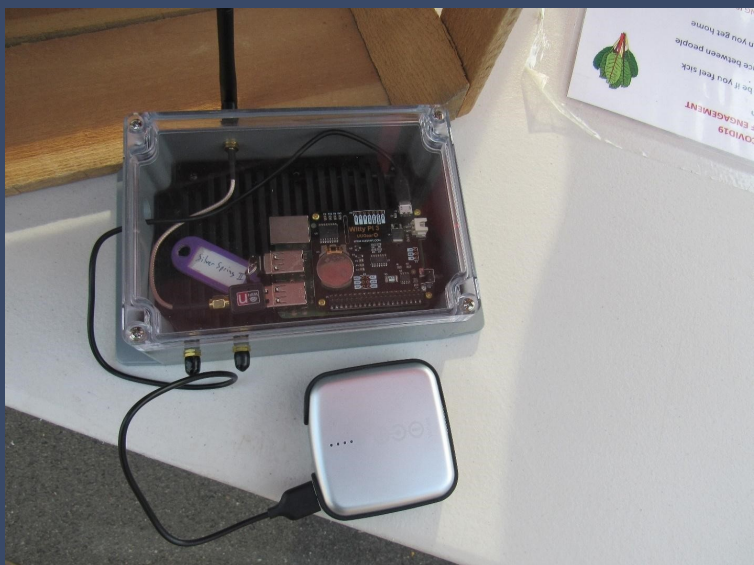


Figure 1. Picture of Ping Counter Device

with a way to estimate the number of visitors that they can integrate into market-level programming.

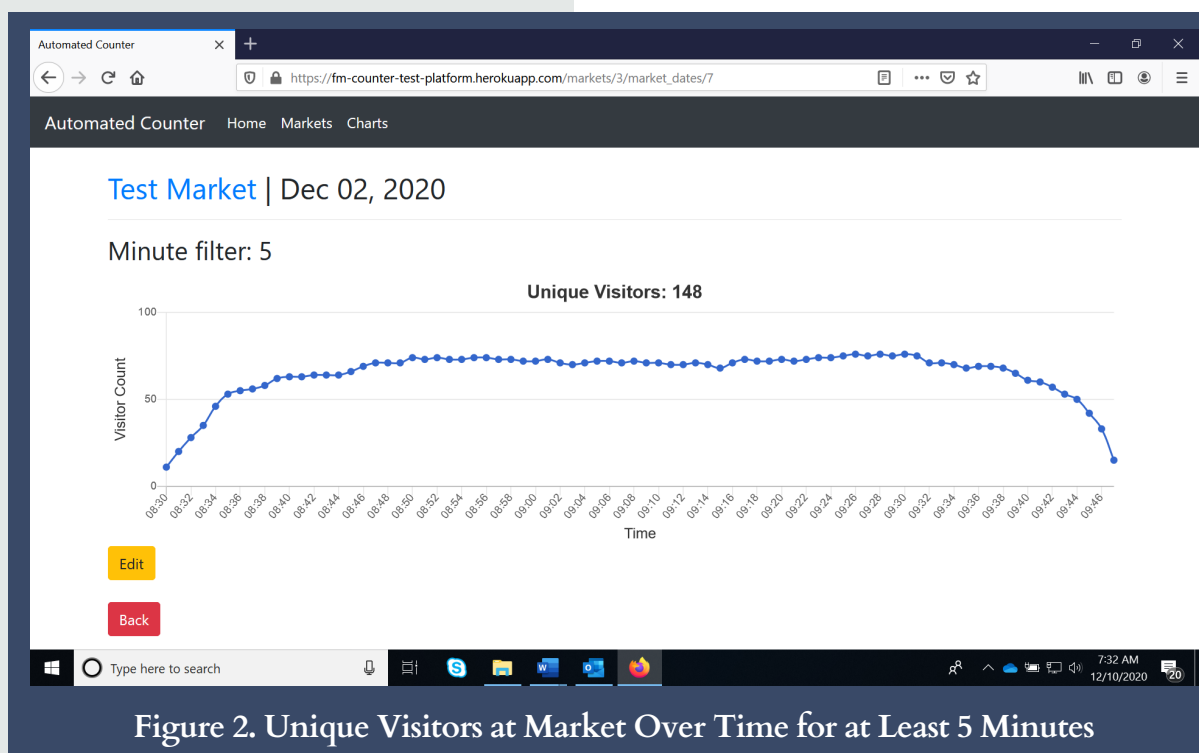


Figure 2. Unique Visitors at Market Over Time for at Least 5 Minutes

Comparing Cell Phone Ping Counts to Manual Counts

Farmers markets are resource-constrained and have to carefully assess the trade-off between the cost of counting visitors and the accuracy of the result. Three summary points are:

- All of the techniques we review estimate the number of market visitors, which include both paying customers and people at the market that do not make purchases;
- It is difficult to compare the accuracy of ping counting devices with manual counting methods; and
- Ping counting devices entail more up-front effort to implement than manual counting methods but require little effort while the market is occurring.

Regarding the second point, the source of the imprecision between ping and manual counts

comes from different sources (Table 1). For instance, double counting is probably less likely a concern with counting cell phone pings, except for people that carry two cell phones in their pocket, than with manual counts. Conversely, counting cell phone pings will miss visitors that do not have cell phones, whereas those visitors could be reported in manual counts.

Also, counting cell phone pings could potentially capture pedestrians beyond the market perimeter if the antennae range extends beyond the market or miss visitors within the market if the antennae range does not extend to the market boundaries.

On the third issue, manual counting methods incur little up-front effort and cost outside the market hours but take considerable effort to implement while the market is underway.

Most critically, during the COVID-19 pandemic, farmers market managers have needed to increase their time and effort at managing markets with social distancing protocols. In comparison, once a farmers market acquires or builds a ping counter, the

device can be operated at each market day for the duration of the market day provided there are no technical glitches that prevent the machine from operating.

	Walk-Around Counts	Timed Entry Counts	Cell Phone Ping Counts
Up-front costs	Low (hand-clicker)	Low (hand-clicker)	Moderate (counting device)
Market-day effort	Moderate	High	Low
Potential to implement method for each market-day of year	High	Low	High
Potential to implement method for the duration of the market-day	Low	Low	High
Possible to count non-shoppers inside the market	Yes	Yes	Yes
Possible to count crowds/lines outside the market	No	No	Yes
Possible to double-count visitors	Yes	Yes	No
Possible to count visitors that do not have cell phone	Yes	Yes	No
Main assumptions needed to estimate market visitors	Must assume a) the average length of stay for visitors to extrapolate and b) that visitors do not move around market during the count	Must assume a) time intervals for counting are representative and b) comprehensive coverage of entry points	Must assume there are not a) visitors outside of the antenna's range and b) non-visitors within the antenna's range
Techniques to improve accuracy of method	Conduct walk-around counts at greater frequencies	Extend the time interval for the count	Implement more than one ping counting device at the market
Potential for human error in counting	High	Moderate	Low
Potential for technological glitches in counting	Low	Low	Moderate
Post-market data entry requirements	Some	Some	None

Table 1. Comparison of Counting Methods for Farmers Market Visitors

Conclusion

While helpful for farmers markets managers before COVID-19, visitor counts became an increasingly important mechanism for farmers market managers during 2020, even though fewer resources were available to undertake manual counts. In this Innovation Brief, we introduce a pilot device that could provide market managers with an automated low-cost method for them to develop estimates of

market visitors. In this Innovation Brief, we introduce a pilot device that could provide market managers with an automated low-cost method for them to develop estimates of market visitors. Further efforts are needed to assess how accurate the devices are and provide guidance for managers on how they can be deployed. Still, ping counting devices represent a promising new way for managers to estimate visitors and may become a commonly used tool by farmers market managers in the future.

Building Better Beyond: *Opportunities and Considerations*

Ping counting devices have the potential to build databases of historical market traffic flows. This data can include hourly, daily, weekly, holiday, and seasonal visitor counts. These data can help market managers document and understand a) disruptive impacts from COVID-19 and b) positive interventions aimed at increasing market traffic. A market management program that can accurately and efficiently forecast changes in traffic will be better prepared to anticipate the support resources that may be needed by the market during heavy traffic days. As more markets adopt ping counting technologies, opportunities for sharing data and experiences to create best practices are likely to emerge. This can include shared observations about customer traffic changes along with things like weather, community events, market promotions, and changes to physical layout.

This innovation brief was created in fulfillment of a cooperative research agreement between the Marketing Services Division of the Agricultural Marketing Service of the United States Department of Agriculture (USDA AMS), the University of Kentucky, Colorado State University and Penn State University.



PennState



United States
Department of
Agriculture

Thanks for reading!

For more information and resources on *Local and Regional Food Systems Response to COVID: Building Better Beyond*, visit: <https://lfscovid.localfoodeconomics.com/> where you can sign up for our project listserv, read other innovation briefs, and check out resources put forth by other sectors of the local and regional food system.

Special thanks to the following organizations for contributing to this innovation brief:



FRESHFARM

References

Donovan, C., and K. Kinney. 2016. Counting shoppers at your farmers market. Washington State Farmers Market Association: Seattle, WA. Available online [here](#) (accessed October 20, 2020).

Lev, L., L. Brewer, and G. Stephenson. 2008. Tools for Rapid Market Assessments. Oregon State University Oregon Small Farms Technical Report No. 6. Available online [here](#) (accessed May 5, 2020).
Wolnik, D. 2017.

Counting visitors at markets. Farmers Market Coalition: Albany, CA. Available online [here](#) (accessed October 20, 2020).

Reviewed by: Dr. Tim Woods, University of Kentucky and Dr. Jairus Rossi, University of Kentucky

Design by: Emily Spencer, University of Kentucky Cooperative Extension

Citation: Wolnik, Darlene and Dutton, Nony and O'Hara, Jeffrey (2021). Estimating Farmers Market Visitors by Counting Mobile Phone Pings. University of Kentucky AEC Extension Publication LSF-IB-10, February.

The findings and conclusions in this innovation brief are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy. USDA is an equal opportunity provider, employer, and lender.

Educational programs of Kentucky Cooperative Extension serve all people regardless of economic or social status and will not discriminate on the basis of race, color, ethnic origin, national origin, creed, religion, political belief, sex, sexual orientation, gender identity, gender expression, pregnancy, marital status, genetic information, age, veteran status, or physical or mental disability.