Using the Counter Graph Area Method to Estimate the Number of Users on The Legacy Trail and Venetian Waterway Park Trail

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Stephen Martin, Ph.D.

1. Introduction

A new method for calculating trail usage from counter data, called the Counter Graph Area Method, has been developed in Reference [1]. Compared to the currently used statistical method developed in Reference [2], the new method is far simpler to understand, easier to apply, has broader applicability, and requires fewer assumptions about how people use the trail.

In the present report a specific implementation of the method is developed that can be used to estimate the number of users on The Legacy Trail and Venetian Waterway Park (VWP) trails.

2. Background

In 2011 Friends of The Legacy Trail (FLT) bought and installed five TrafX automatic traffic counters at points on The Legacy Trail (LT) and Venetian Waterway Park (VWP). At that time it was recognized that counter results do not directly measure trail usage[1]. Some people may pass several counters, while others do not pass any counter. A method for addressing this issue was initially developed by Steve Christian in Reference [3]. His method was used to calculate the number of users on the LT and VWP until 2017.

Because some of the original counters were failing and the accuracy of others was suspect, FLT took a fresh look at the subject of usage measurement in 2017. A part of this

[1] Other trails only report counts on their counters, or report usages as equivalent to counts compensated by the number of out-and-back trips.

study was the development of the statistically based method for calculating trail usage documented in Reference [2]. That method has been used to calculate trail usage for 2017 and 2018. One of the disadvantages of this method is that it is complex and requires the use of a numerical analysis computer program to obtain results. Because of this complexity, and other limitations, the new Counter Graph Area Method was developed in Reference [1].

3. Calculating the Number of Users of the Legacy Trail and Venetian Waterway Park

In Reference [1] it is shown that a fundamental relation between counter readings and the number of trail users is expressed by the equation

$$N_u = \frac{A}{\mu} \tag{3.1}$$

where N_u is the number of users, μ is the average distance traveled by trail users on the trail, and A is the area under the counter curve. The counter curve is the graph of counter values that would be obtained if there were a counter at all points on the trail. In practice, we approximate the area under the counter curve from only a few points on the curve where we actually have counters. Methods for approximating the counter curve from a few points are given in Reference [1].

For the present analysis, we will treat The Legacy Trail and the eastern (mainland) part of the Venetian Waterway Park (VWP) as a single trail, and the western (island side) of the VWP will be treated as a separate trail.

4.1 The Legacy Trail and Eastern VWP

For this stretch of the trail there are currently three trail counters located approximately at the locations shown in Figure 1. The x-coordinates on the graph represent locations on the trail in miles. The origin, or zero mile point, is taken to be the start of The Legacy Trail. This means that the south end of the Venetian Waterway Park trail is at mile -3.9 in this coordinate system.

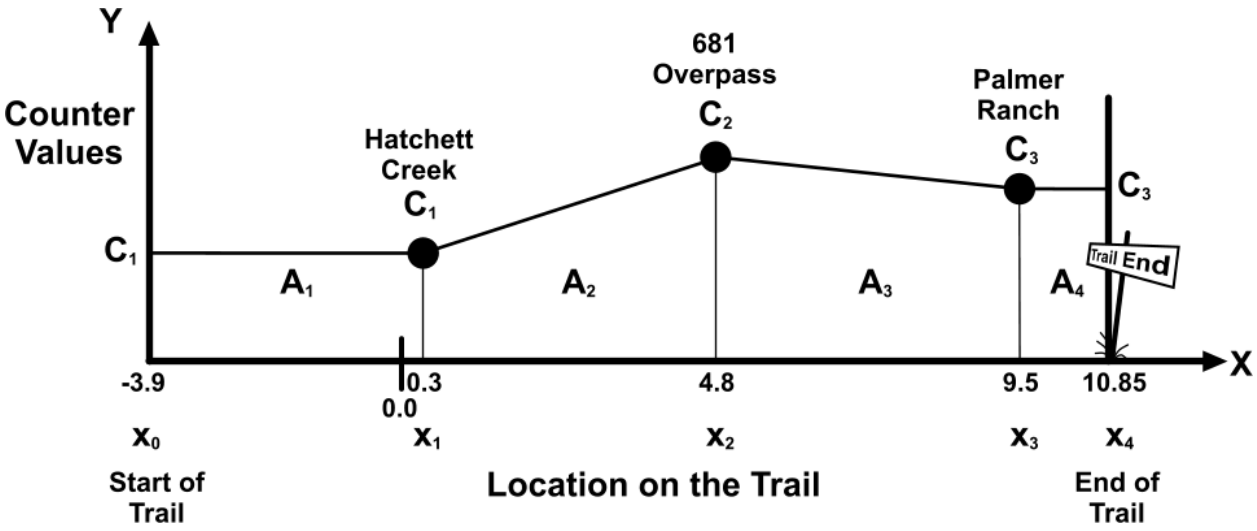

Figure 1 – The Approximate Counter Graph

The current locations of the three counters are also shown. The y-values shown represent typical counts on the counters. The counts on the Hatchett Creek, 681 Overpass, and Palmer Ranch counters are denoted C_1, C_2, and C_3, respectively.

The current location coordinates are:

Location	Symbol	x-Coordinate (miles)
Beginning of Trail (Shamrock Park)	x_0	-3.9
Hatchett Creek Counter	x_1	0.25
681 Overpass Counter	x_2	4.8
Palmer Ranch Counter	x_3	9.5
North End of Trail	x_4	10.75

Table 1 – Counter Locations

As discussed in Section 3.3 of Reference [1], we can approximate the counter curve by connecting the counter points with straight lines. The curve is assumed to have the constant value C_1 from the start of the trail to the Hatchett Creek counter, and have the value C_3 from the Palmer Ranch counter to the end of the trail. In other words, the curve is a horizontal line in these regions.

The area under the counter curve is just the sum of the areas A_1, A_2, A_3, and A_4. Since formulas for the areas of these trapezoidal shapes are known, it can be shown that the total area, A, is given by

$$A = C_1(x_1 - x_0) + \left(\frac{C_1 + C_2}{2}\right)(x_2 - x_1) + \left(\frac{C_2 + C_3}{2}\right)(x_3 - x_2) + C_3(x_4 - x_3) \tag{3.2}$$

By rearranging terms, this equation can be put in the form

$$A = W_1 C_1 + W_2 C_2 + W_3 C_3 \tag{3.3}$$

where C_1, C_2, and C_3 are the counts on the counters and the weighting factors, W, are given by

$$W_1 = \left[-x_0 + \left(\frac{x_1 + x_2}{2}\right)\right] \tag{3.4}$$

$$W_2 = \left[\left(\frac{x_3 - x_1}{2}\right)\right] \tag{3.5}$$

$$W_3 = \left[x_4 - \left(\frac{x_3 + x_2}{2}\right)\right] \tag{3.6}$$

where x_0 through x_4 are the coordinates defined in Table 1.

Since the values of the coordinates x_0 through x_4 are known (see Table 1), we can evaluate the weighting factors, W, to obtain

$$W_1 = 6.44, \qquad W_2 = 4.62, \qquad W_3 = 3.6 \tag{3.7}$$

Substituting these values of the weighting factors into Equation (3.3) gives the desired equation for the area under the curve:

$$A = 6.44C_1 + 4.62C_2 + 3.6C_3 \tag{3.8}$$

As derived in Reference [1], the number of users is just this area divided by the average distance, μ, traveled on the trail by users. The most recent estimate we have for this distance was obtained using an online survey of trail users in April 2018. The data from this survey showed an average distance traveled of 15.4 miles.

Dividing the expression for the area given in Equation (3.8) by this distance, the number of users on the eastern (mainland) segment of the trail, N_E, is given by

$$N_E = 0.42C_1 + 0.3C_2 + 0.23C_3 \tag{3.9}$$

where C_1, C_2, and C_3 are the counts on the counters. This equation is the fundamental equation for calculating the number of users on the combined LT and eastern VWP from the counts on the counters.

Example

The counts for January 2019 were

Table 2

Location	Symbol	Counts for 1/2019
Hatchett Creek Counter	C_1	20,547
681 Overpass Counter	C_2	28,463
Palmer Ranch Counter	C_3	23,849

Entering these count values into Equation (3.9) gives

$$\begin{aligned} N_E &= (0.42)(20{,}547) + (0.3)(28{,}463) + (0.23)(23{,}849) \\ &= 22{,}654\ users \end{aligned} \tag{3.10}$$

Note that Equation (3.9) will not normally change from month to month. It will only change if a counter is moved, if the estimate for the average distance traveled changes,

or if the length of the trail changes. Therefore, generally all one has to do to calculate the number of users is put the counts from the counters into Equation (3.9). The number of users in then easily computed with just a calculator.

4.3 The Island Side of the VWP

The island side of the VWP will be treated as a separate trail. There are two main reasons for doing do this:

1. This side of the trail is connected at many points to the commercial center of Venice, and it is judged that there will be more people who use the trail for only a portion of their trip. This results in a smaller average distance traveled on this section. It will be assumed that the average distance traveled by a user on the island side is a fraction, r_d, of the distance traveled by users on the mainland side. In the example calculation below, the value r_d is taken to be 0.5.
2. Only a small fraction of people will use both the eastern and western sides of the trail on a single trip. The fraction of the total number of users who go on both sides of the trail in a single trip will be denoted r_b. In the example calculations below the value of r_b is assumed to be 5%, or 0.05.

At present there are no counters on the western VWP side. However, from Reference [3], counts taken from 2011 to 2013, when there was a single counter on that side, gave values that were about half the values of counters on the mainland side. We will make the assumption that if there were a counter on the island side its value would be a fraction r_c of the average of the counters on the mainland side. In other words, the value of this "virtual" counter would be

$$C = r_c\left(\frac{C_1 + C_2 + C_3}{3}\right) \tag{3.11}$$

We will also assume that this counter is located in the center of the length of this segment of the trail.

In Reference [1] it is shown that for the case where there is just one counter, the area, A_W,under the counter curve is best approximated by

$$A_W = L_W C \tag{3.12}$$

where L_W is the length of the western (island side) segment of the VWP, and C is the count on the (virtual) counter on that segment.

Substituting our assumed value of the virtual counter, Equation (3.11) into Equation (3.12), the area A_W under the counter curve is given by

$$A_W = r_c L_W \left(\frac{C_1 + C_2 + C_3}{3}\right) \tag{3.13}$$

where L_W is the length of the western trail, and r_c is the fraction that multiplies the average of the mainland side counts to give the count on the western side virtual counter.

To get the equation for the number of users, we divide Equation (4.13) for the area, by the average distance traveled on the western side. Recalling that the average distance traveled on the western side is assumed to be $r_d\mu$, the usage for this segment of the trail will be given by

$$N_W = \left(\frac{r_c L_W}{r_d \mu}\right)\left(\frac{C_1 + C_2 + C_3}{3}\right) \tag{3.14}$$

where

- N_W is the number of users on the western VWP trail segment,
- $r_d$is the ratio of the island side distance traveled to the mainland side distance traveled,
- μ is the average distance traveled on the mainland side,
- r_c is the ratio of the count of the virtual counter on the western VWP to the average of the counts on the mainland-side counters, and
- The C terms are the mainland counter readings.

Example

The following parameters will be used:

- The length of the VWP western segment, L_W,is 5.5 miles.
- We will again use the counter data for January 2019 given in Table 2.
- It is assumed that if there were a counter on the western VWP segment, it would read ½ the average value of the average of the mainland-side counters (i.e., $r_c = 0.5$).
- It is assumed that island –side users only travel half as far on the trail as main-land-side users (i.e., $r_d = 0.5$), and
- The average distance traveled on the mainland-side trail is 15.4 miles.

Substituting these values into Equation (4.14) gives

$$N_W = \left(\frac{(0.5)(5.5)}{(0.5)(15.4)}\right)\left(\frac{20{,}547 + 28{,}463 + 23{,}849}{3}\right) = 8674\ users \quad (3.15)$$

4.4 The Total Trail Usage

Now that we have the usages for both the mainland and island trail sections it might seem that we could just add them together to get the total usage. We will do this, but we need to make a small correction to account for the fact that some people will travel on both trails in a single trip. These people would add one usage to both the mainland-side and island-side trail counts, and therefore be counted as two users. Therefore, the total trail usage, N_T, is given by

$$N_T = N_E + N_W - N_{both} \quad (3.16)$$

where N_E is the number of users on the eastern (mainland) side, N_W is the number of users on the eastern (island) side, and N_{both} is the number of people who travel on both sides in a single trip.

Next, we assume that the number of people who travel on both trails is a fraction, r_b,of the total number of trail users, i.e., $N_{both} = r_b N_T$. Substituting this expression for N_{both} into Equation (3.16) gives the equation

$$N_T = N_E + N_W - r_b N_T \tag{3.17}$$

Since N_T appears on both sides of the equation, solving this equation for N_T gives the solution

$$N_T = \frac{N_E + N_W}{1 + r_b} \tag{3.18}$$

This equation gives the total usage for The Legacy Trail and VWP.

Example

The number of users for the eastern (mainland) and western (island) trails have already been calculated for January 2019 in the previous examples. If we assume that 5% percent of users travel on both trails in a single trip, the total number of users, N_T, is given by

$$N_T = \frac{22{,}654 + 8{,}674}{1 + 0.05} = 29{,}836\ total\ users \tag{3.19}$$

4.5 Total Usage for the Legacy Trail and VWP for the Years 2017 and 2018

The implementation of the Counter Graph Area (CGA) Method described in this report was used to calculate the yearly usage for 2017 and 2018. In these calculations the following assumptions were made:

1. A counter on the island side would read $1/2$ the value of the average of the counts on the mainland side.
2. The average distance traveled by users on the island side is $1/2$ the average distance traveled by mainland-side users.
3. Only 5% of the total usages are trips on both the mainland and island sides.

4. The average distance traveled per trip by mainland-side users is 15.4 miles.

Table 1 compares the usage calculated with the CGA method with usage from both the C2D and C2A computer models documented in Reference [2].

	C2D Computer Model	**C2A Computer Model**	**CGA Model (This Report)**
2017	227,690	223,456	220,881
2018	215,943	216,357	216,250

Table 1

This table shows that the CGA model is in good agreement with the computer models that have been previously used to calculate trail usage in 2017 and 2018.

5. Summary

The procedure for calculating trail usage for a one-month period entails the following steps:

1. Read the counters and upload the data to the manufacturer's web site.
2. Inspect the data to see if each day's numbers look reasonable and correct the data by interpolation if necessary. For each counter, sum the daily totals to arrive at the months count for each counter.
3. Correct the counter totals by multiplying each counter's sum by a correction factor that accounts for normal undercounting. This provides a more accurate estimate of the count.
4. Calculate the W factors from Equations (3.4), (3.5), and (3.6).
5. Calculate the usage for the mainland and island-side trails using Equations (3.3) and (3.14).
6. Calculate the total usage using Equation (3.18).

References

1. Martin, Stephen, (2019, February 27),“A Simple Method for Calculating Trail Usage from Counter Data,” https://www.friendsofthelegacytrail.org/wp-content/uploads/2018/02/Statistical-Models-2.pdf, (March 18, 2019)

2. Martin, Stephen, (2017, January 17),“Calculation of Trail Usage from Counter Data.” https://www.friendsofthelegacytrail.org/wp-content/uploads/2018/02/Statistical-Models-2.pdf, (accessed, February 18, 2019)

3. Christian, Steve, (2014, January 11), “Legacy Trail and Venetian Waterway Park User Count Report,” https://www.bikeveniceflorida.com/legacy-trail-vwp-user-count-summary/2011-2013-lt-vwp-user-count-report/ , (accessed, February 28, 2019)