Estimating Daily Exiting Traffic from National Forest Recreation Sites Using Short-term Observational Counts

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Introduction

Since its inception, the Forest Service's National Visitor Use Monitoring (NVUM) program has based its visitation estimates on a random sample of daily (i.e., 24-hour) mechanical traffic counts, calibrated by a combination of 6-hour observational counts and interviews (English, et al., 2002; Zarnoch, et al., 2011). Mechanical counters have inherent measurement errors and fail for an array of reasons. In addition, about 20% of the NVUM field data collection costs are tied to the use of mechanical counters.

Our goal was to develop estimates of daily (24-hour) exiting traffic volume using just the 6-hour observational count of exiting traffic and two variables from the interviews. More exactly, our goal was to develop 24-hour estimates from the 6-hour counts that were equivalent to the estimates generated from the current NVUM method. If our work was successful, we could eliminate the data quality issues and costs of the mechanical counters without appreciably changing the resulting estimates of visitation. We present our analytic process and results, and an evaluation of how well the process worked.

Data and Analysis

Interviewers record the starting and ending times for their 6-hour onsite interview period and keep a running tally of exiting traffic on a handheld counter. To start each interview, the interviewer records the time and exiting traffic value from hand counter. These function as time-stamped observations of exiting traffic volume. We interpolated the exiting rate between individual surveys to estimate the traffic exiting during each one-hour segment of the interview period. Assigned survey times vary from one day to the next and, in aggregate, cover nearly all of the daylight period in each season for each stratum within each forest.

For each forest, NVUM sampling strata of site-days are defined by up to 4 types of sites and up to 4 exiting traffic levels. We also grouped site-days across the country according to four seasonal definitions and four latitude groups to account for variation in length of daylight period through the year. As a result we had 256 potential groupings. Not all of these groupings existed in the field data; we had to estimate parameters for 184 groups.

Using a national set of data from FY2010 through FY2014, we calculated the mean exiting traffic counts for each hour for which we had field data on exiting traffic in each group-sampling stratum combination. Mean exiting volume per hour over the hours in the aggregate survey window was converted into a probability mass function and modeled using a beta distribution. Beta models have been used natural resource applications, including outdoor recreation (Zarnoch, English, and Kocis 2005). To account for twilight exiting traffic not observed in the empirical data we expanded the hours modeled to include the hour before and after daylight. The beta distribution is defined as

$$f(p) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(a)} p^{a-1}(1-p)^{b-1} \qquad 0 < p < 1 \qquad a > 0 \quad b > 0$$

$\Gamma(z)$ is the gamma function evaluated at z.

The method of moments is used to estimate the beta parameters as

$$\hat{a} = \bar{p}\left(\frac{\bar{p}(1-\bar{p})}{\hat{v}} - 1\right) \quad \text{and} \quad \hat{b} = (1-\bar{p})\left(\frac{\bar{p}(1-\bar{p})}{\hat{v}} - 1\right)$$

An out-of-sample validation test was completed using data from FY2005 – FY2009 to ensure beta parameters were robust through time. For nearly all groups, the beta parameters were not significantly different over time. Final beta models were estimated using 10 years of data (FY2005 through FY2014 inclusive).

Results and Discussion

Figure 1 shows an example, the empirically derived hourly proportion of daily exiting traffic for the group of site-days defined by Middle latitude (between 40 and 45 degrees), Spring (April, May, June), General Forest Area dispersed recreation sites, and High daily exiting recreation volume. The recreation day for this group lasted 15 hours, from 0600 to 2100; the average exiting traffic volume per day was about 72 cars. The beta model of predicted exiting proportion is superimposed to compare the modeled hourly proportion to the actual. Sum of proportions over all hours equals 1.0.

Employing the beta model results to estimate 24-hour exiting traffic from a 6-hour interview window is straightforward. First, calculate the expected proportion of daily exiting traffic that occurs during the interview period. Consider a survey day starting at 0800 and ending at 1400, which is a commonly assigned survey window for NVUM. Assume that the interviewer observed 25 exiting vehicles. The model used in Figure 1 indicates that the sum of probabilities in that time window accounts for an expected 41.04% of all exiting traffic. Multiplying the observed exiting volume by (1.00/0.4104) gives the expected exiting traffic volume for the 24-hour period, or 60.92 vehicles.

The national average for beta method traffic means were about 20% less than the current method. The current method includes traffic exiting during nighttime, but the beta method only reflects daytime and twilight exits. We applied a ratio adjustment by forest and sampling stratum to bring the means into closer alignment. We performed a second out-of-sample test using field data from FY15/FY16 combined. Again, the beta parameters were not significantly different for nearly all groups. More importantly, comparing the ratio-adjusted beta method to the current NVUM method yielded a correlation coefficient of 0.94; the average deviation in estimates of exiting traffic was under 5%.

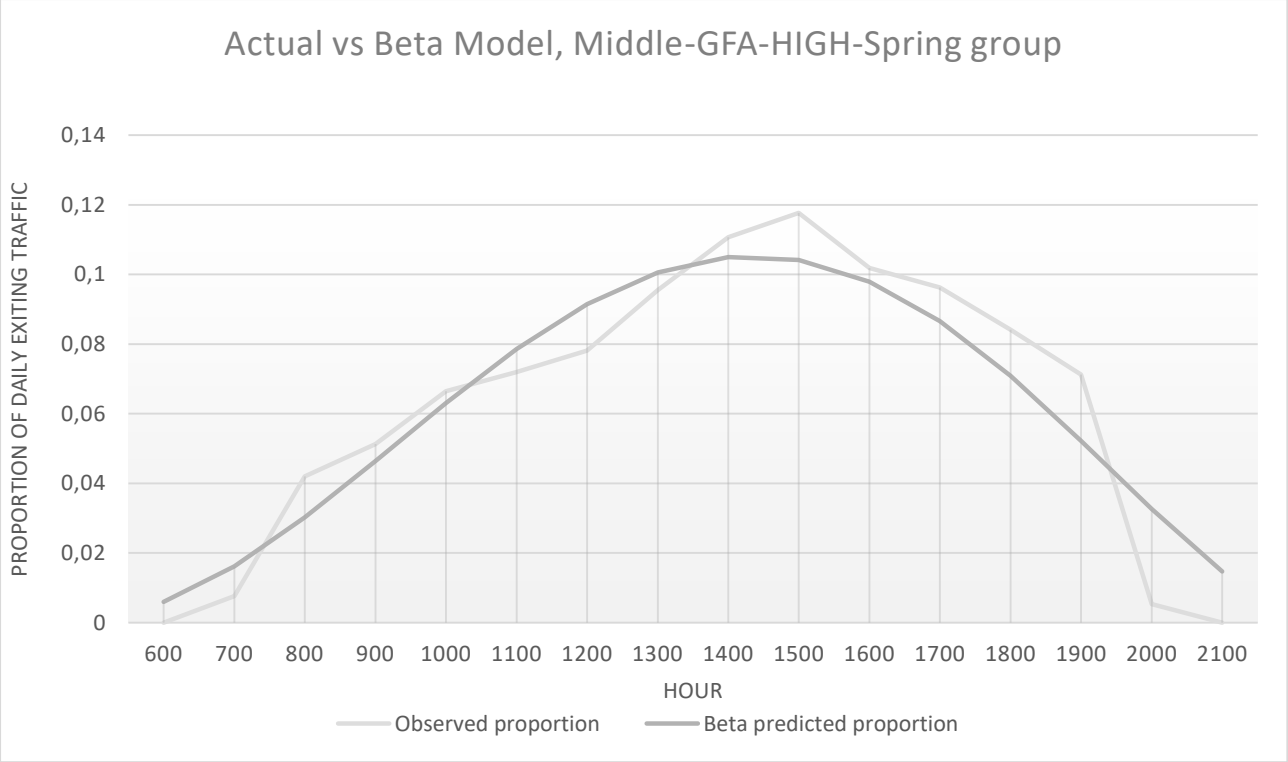

Figure 1. Empirical and beta-modeled hourly proportion of exiting cars for group Middle-Spring-GFA-High.

The results are more than adequate for our needs. Starting in October 2019 at the beginning of the next national data cycle, the NVUM program will eliminate the use of mechanical traffic counters entirely. Instead, estimates of daily exiting traffic counts will come from the ratio-adjusted beta means. This change eliminates national overhead costs of maintaining a cache of traffic counters for use by forests during their field year. The current field protocol is to set up the mechanical counter, complete a 6-hour observation and interview period, and go home. The next day, retrieve the counter after it was in place for 24 hours. The modeling approach eliminates the second trip to the interview site, often an hour's travel.

References

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