Monitoring and Management of Visitor Flows in Recreational and Protected Areas
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Visitor Use of USDA Forest Service Recreation Areas: Methods and Results from the National Visitor Use Monitoring Effort

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Abstract: One stratum of survey sites in the USDA Forest Service's National Visitor Use Monitoring (NVUM) effort contains agency-managed elements of the National Wilderness Preservation System. Two related methods are used to estimate the amount of visitation that occurs in these areas. One utilizes annual information on the number of use permits at the sites where these are mandatory; the other employs a double-sampling approach to estimate visitation. In both cases, on-site visitor sampling is required to obtain the information necessary to estimate actual visitation. A few additional questions on the survey enable us to describe visitor demographics, evaluate customer satisfaction, and estimate economic values and impacts of these visits.

The presentation discusses development of the sampling design as well as calibration issues for both use estimation methods. A comparison of the statistical accuracy and cost of each is made. Because the sample design is based on the spatial-temporal combination of Wilderness exit points and the days they are open, some analytic adjustment to the sample survey data is required (beyond simple sample means) to get results that describe the visiting population. The analytic framework is presented, along with some empirical results from the first year of sampling at six selected National Forests to give the flavor of the managerially-relevant information we have so far obtained. The presentation concludes with a discussion of how we plan to extend the analysis that can include issues such as developing models of visitor flows and relating visitation levels to perceptions of crowding.

INTRODUCTION

One of the goals assigned to the National Visitor Use Monitoring (NVUM) team in developing estimates of the volume of visitation that occurs on USDA-Forest Service lands was to be as accurate as possible, i.e., to try to minimize the error associated with the visitation estimate. This was an important but substantial issue, given the expected size of the quantity to be estimated, and the scope of agency lands to be covered each year. One way our research project tried to do that was to make use of visitation-related annual counts that are routinely compiled by the agency at some of its recreation sites. Examples of information that can serve as a proxy for the level of visitation include: permanent traffic counters along roadways at trailheads or at developed sites such as visitor centers, mandatory permits to be able to use some wilderness areas, fee envelopes or concessionaire records at developed campgrounds, fee receipts charged at some day use sites, downhill ski areas, usage reports for cabins or lodges, and special use permits obtain for use of certain facilities. Usually, sites that have reliable information of this type are more heavily used than those sites that do not.

The primary intent in incorporating the additional data was to reduce the overall variability in the visitation estimate for national forests. Since annual counts for visitation proxy information were known without error, variability would come only from calibrating the proxy counts to visits. For example, traffic counts must account for variation in number of people per vehicle, and the proportion of non-recreating vehicles. This paper examines the statistical efficiency of the types of visitation proxy information used in the first year's data collection. We compare the variability of estimates for sites that had some sort of visitation proxy to the sites that did not.

RESEARCH METHOD

We outline only the basics of our method here. More detail can be found at the NVUM website version of our methods paper (http://www.fs.fed.us/recreation/recuse/methods/methods052001.rtf). The basic research unit was a national forest. In the U.S., there are about 125 national forests which jointly manage about 192 million acres of forests and grasslands. We sample forests on a five-year cycle. About one-fourth of

	Non-proxy Site Days		**Proxy Site Days**	
Forest	Sampled	Population	Sampled	Population
Beaverhead - Deerlodge	170	47,965	23	6,001
Flathead	187	36,714	21	4,441
Nez Perce	147	38,284	0	0
Rio Grande	123	44,158	14	3,468
San Juan	150	36,453	10	6,267
Arapaho	173	106,998	9	1,379
Cibola	169	66,135	15	5,800
Coconino	206	48,191	35	8,274
Kaibab	101	14,294	21	3,121
Boise	123	49,634	40	9,804
Caribou -Targhee	152	125,530	23	4,883
Sawtooth	122	29,605	24	2,439
Humbolt - Toyiabe	215	331,830	18	5,685
Angeles	231	31,940	45	8,409
Lassen	162	19,255	12	5,892
Modoc	143	13,200	11	2,038
Plumas	158	18,669	14	5,965
Mt. Baker - Snoqualmie	119	29,433	18	9,986
Ochoco	166	25,098	17	4,435
Okanogan	184	25,265	2	61
Olympic	171	21,954	25	5,765
Columbia Gorge	152	13,599	9	906
Florida	109	101,959	25	4,760
George Washington - Jefferson	205	122,340	27	3,828
Ouachita	161	163,009	0	0
Carribean	41	5,124	4	365
Superior	153	37,313	20	17,642
Hiawatha	139	41,140	16	3,998
Green Mtn. - Finger Lakes	221	67,885	10	1,229
White Mtn.	160	42,236	45	12,592
Tongass	133	42,563	11	12,352
TOTAL	4,846	1,797,773	564	161,984

Table 1. Sample size for the first sample year (CY2000), by forest.

the forests are sampled each year. The fifth year allows time to revise and improve the research process. During calendar year 2000, 31 different forests were involved with sampling.

The primary sampling frame was the spatial-temporal combination of a recreation site and a calendar day on which people visit the site. Each sampled national forest first identified every developed recreation site, such as campgrounds and picnic areas, as well as wilderness trailheads and access points to the general forest area. For each site, every day in the year that the site was open was assigned to one of three sampling strata (high, medium, or low), according to the level of exiting recreation traffic. In addition, each site-day was classified as to whether some credible visitation proxy existed (proxy site-days) or not (non-proxy site days). Proxy site days were then stratified according to the type of use proxy information, rather than by use level.

For non-proxy site days, the number of daily exiting visits was estimated using a double-sampling method. A traffic counter was placed at the site for 24 hours. Interviews occurred during a six-hour period, to determine the proportion of traffic that was completing a recreation visit, and the average number of persons per vehicle. Mean and variance of daily visitation were calculated across all days in a sampling stratum, and expanded to the forest population of site days in that stratum.

Visitation for proxy site-days was estimated somewhat differently. On sample days, no 24-hour traffic count was used. Instead, surveys were conducted to obtain a daily estimate of a calibration coefficient for the proxy information. Mean and variance of the calibration coefficient for a sampling stratum were calculated across all of the sample days in the proxy stratum, and expanded to the total forest count for that type of use proxy, summed across all sites that used the proxy.

Table 1 shows the size of the site day population and number of sample days for both proxy and non-proxy strata on each sampled forest. In general, proxy days made up ten to fifteen percent of the sample size in forests that had proxy site days. The overall sampling rate for proxy site days was somewhat larger than for all nonproxy days. The reason for this is that most of the non-proxy site days were in low exit volume categories that were sampled at a much lower rate than were the medium or high exit volume categories. By contrast, very few proxy days were classified as having low exit volume of visitors.

EVALUATION OF PROXY DATA

We expected there would be less variation in the calibration coefficient across sample days in proxy strata than there would be in daily visitation estimates for non-proxy strata. Thus, incorporating the proxy data into our research design was expected to reduce the variance in the total visitation estimate for each forest. To evaluate whether this was true or not, we chose to compare coefficients of variation (CV) for non-proxy versus proxy strata for each forest. The coefficient of variation (CV) was used as a measure of the precision of the visitation estimate and is defined as

$$CV = 100 * \frac{\sqrt{VAR}}{TOTAL}$$

The CV shows the variance of an estimate relative to the size of the estimate itself. For our purposes, we expect CV for visitation estimated for site days for which there is proxy data to be much lower than those for visitation estimates for site days that do not have proxy data.

FOREST	Non-proxy CV	Proxy CV	Total CV	Current	Sample Size: Needed to reach Total CV without proxy data
Beaverhead - Deerlodge	19.44	8.92	17.56	193	186
Flathead	12.13	14.38	9.49	208	279
Nez Perce	19.14	--	19.14	147	147
Rio Grande	31.28	5.81	28.25	137	134
San Juan	11.84	6.20	11.22	160	193
Arapaho	18.72	1.96	9.42	182	197
Cibola	19.40	2.07	17.29	184	243
Coconino	14.70	4.31	11.21	241	291
Kaibab	31.20	7.18	24.41	122	134
Boise	23.19	14.38	12.64	163	515
Caribou -Targhee	19.70	9.40	17.88	175	167
Sawtooth	17.04	6.11	10.06	146	305
Humbolt - Toyiabe	19.25	7.09	15.87	233	211
Angeles	14.66	6.01	10.36	276	389
Lassen	21.13	12.26	18.87	174	207
Modoc	21.80	13.69	20.34	154	169
Plumas	19.53	7.72	18.06	172	201
Mt. Baker - Snoqualmie	14.08	18.46	13.72	137	130
Ochoco	16.04	29.90	18.12	183	181
Okanogan	21.16	0.00	20.32	186	203
Olympic	18.96	2.47	12.73	196	401
Columbia Gorge	15.34	27.73	13.94	161	195
Florida	19.23	0.42	15.54	134	185
George Washington - Jefferson	11.40	6.05	11.10	232	225
Ouachita	13.66	–	13.66	161	161
Carribean	35.46	8.72	34.74	45	45
Superior	14.34	1.97	13.31	173	208
Hiawatha	13.58	9.22	12.36	155	165
Green Mtn. - Finger Lakes	17.18	5.12	12.86	231	364
White Mtn.	12.29	32.95	23.33	205	199
Tongass	25.90	9.09	25.81	144	167

Table 2. Comparison of coefficient of variation (CV), by forest.

The results of this comparison show pretty much exactly what we expected. Across all 31 forests, nearly half had a CV for the non-proxy portion of their visitation between 17 and 21 (Table 2). Three had CV values over 30. The median value was slightly less than eighteen. Across the 29 forests that had proxy data, thirteen had values between 5 and 10, and six forests had values below three. Here, the median value would be just under eight. In nearly every case, the non-proxy CV estimate was improved by the addition of the proxy visitation estimate and its relatively smaller variance. Overall, we used 564 proxy sample days to estimate about 16.6 million site visits on these 31 forests. In the non-proxy strata, we used 4,846 days to estimate about 50.5 million site visits. That is, in the non-proxy strata, we needed eight times as many sample days to estimate three times as much visitation.

There were some unexpected results in the CV comparisons that merited further examination. In particular, there were five forests for which the CV for proxy visitation was larger than for the non-proxy. These forests were the Flathead, Mt. Baker-Snoqualmie, Ochoco, Columbia Gorge, and White Mountain. For each forest, we examined each type of visitation proxy that was used. Two forests, the Ochoco and the Columbia Gorge, included permanent traffic counters on forest roads as proxy information for visitation to parts of the general undeveloped portion of the forest. To calibrate the traffic counts, the interviews obtained two pieces of information. First was the proportion of vehicles on that day that were finishing their recreation visit to the forest. Second was the average number of people in each vehicle that was competing a recreation visit. On the Ochoco, there was a wide range across sample days of the proportion of vehicles that were finishing a recreation visit. Over the 4 days sampled, the proportion ranged from about 40 percent to 100 percent. On the Columbia Gorge, the proportion of exiting traffic that was finishing a recreation visit was more stable, but the daily average number of people per vehicle ranged from just over 1.2 to almost 6.8. Here, it was the combination of daily means of the proportion that were finishing a recreation visit and the average people per vehicle that generated higher variability.

On the Mount Baker- Snoqualmie, the high variability was caused by using number of tickets sold at a large downhill ski area as a visitation proxy. The annual proxy count was just the total number of tickets sold by the ski area. That total included single day tickets, multiple-day (weekend) tickets and a fair number of season passes. Calibration entailed converting number of tickets to number of visits. The problem centered on the season passes. The ski area is within a short drive of metropolitan Seattle. Although about one-quarter of the people interviewed showed a one-to-one correspondence between tickets and visits, a number of people indicated that they used their season pass 50 or more times. The wide range across individuals caused the higher proxy variance for this forest.

On the White Mountain, a downhill ski area near population centers caused a similar, albeit smaller problem. A more significant issue was with a visitation proxy that counted campsite nights occupied. This forest has some campgrounds that have both family-sized sites, and large-group (25 or more people) sites. To convert from campsite occupancy to visits, we needed to multiply by the average camping party size. On some sample days, only small groups and individuals were interviewed, so the average was slightly less than 2.0. On other days, one or more large groups were encountered, so the average party size on those days was about 9. A potential solution for this is to separate large group and small group sites into different sampling strata.

On the Flathead, a small number of sample days caused somewhat higher than expected variance. A severe forest fire led to extensive site closures during a peak use season. Visitation stayed low after the fire closure order was lifted. Consequently, on a number of assigned sample days, there were no visitors to interview. For one type of proxy count in particular, a count of payment envelopes at fee campgrounds, only 2 sample days occurred that had individual visitor data with which to develop calibration coefficients. The daily average conversion from envelopes to visits on one day was about 2.5, but was over 6.1 for the other day. As a result, the variance estimate was quite high. The mean and variance calculated from these two days were expanded to a forest-wide population of over 1400 days.

SAMPLE SIZE REDUCTION

Overall, it appears that using the visitation proxy data was well worth the effort. However, the gains become more tangible if we could estimate how many sample days were saved. Our project allocated about $375 per sample day to forests to accomplish the sampling. Quantifying sample days would allow us to approximate cost savings. To do that, we extrapolate from the non-proxy sample alone to the entire population of site days on each forest. We compute what sample size would be needed to reach the CV level actually observed when both proxy and non-proxy sampling was used.

The determination of the number of non-proxy site days required to achieve a desired CV for a forest surveyed under a stratified random sampling design used three types of information obtained from the original survey. First, the total number of site days (N_h) in each site type-use level stratum was obtained by combining over non-proxy and proxy site days. The strata weights (W_h) were defined simply as the proportion of total site days in

stratum h. Next, strata daily visitation means (y_h y) and variances (s_h^2) were approximated by assuming the estimated means and variances from the original non-proxy survey. Regional averages were used in a few instances where a stratum was based on only proxy site days.

The above quantities were used to derive an estimate of the total number of site visits defined as:

$$TOTAL = \sum_{h=1}^{L} N_h \bar{y}_h$$

with estimated variance defined as

$$VAR = N^2 \sum_{h=1}^{L} \frac{W_h^2 s_h^2}{n_h} - N^2 \sum_{h=1}^{L} \frac{W_h^2 s_h^2}{N}$$

where

N = the sum of the N_h and

n_h = the number of site days sampled in stratum h.

Since TOTAL and VAR are fixed except for the n_h's, a desired CV can be obtained by iteratively adjusting the n_h's until the specified CV is achieved. Summing across strata yields the total sample size n associated with the target level of precision. For simplicity, we simply increased all the n_h's by the same proportion.

The results are found in the last two columns of Table 2. For eight of these forests, eliminating sample days to calibrate proxy counts would allow a reduction their overall sampling burden without sacrificing accuracy. Three of these forests were ones that had high variability in their proxy visit estimate, as discussed earlier. For them, the reduced sample size reflects the relatively lower variability in the non-proxy strata. The other five fell into one of two categories. Two were forests that had similar problems with high variability in estimating visitation from ski area or vehicle traffic proxy counts. The other three were forests where proxy site visitation was less than 10 percent of the forest's total visitation. In this last instance, sampling gains existed because the sample days used to estimate the small amount of proxy visitation would have been better used improving the estimate of the much larger non-proxy visitation. However, on twenty of these forests, not employing the visitation proxy data would have required a larger sample size to achieve the same level of precision. For these forests, using the proxy visitation data reduced the sampling need by an average of over 70 days per forest.

Under the current sampling protocol, there were 5,410 sample days accomplished across the U.S. If the visitation proxy data were not used, nearly 6,800 sample days would be required to have the same accuracy in the estimate for each of the 31 forests. That additional 1,400 sample days translates to an increase of over 25 percent. Accomplishing these extra days would cost over a half-million dollars in staff time. Additional costs would be incurred for printing and mailing survey forms, data entry, and data cleaning.

DISCUSSION AND CONCLUSION

The analyses presented here show that using the visitation proxy information did reduce the overall sampling level that we needed at the national level. The sampling reduction was somewhat more that we had anticipated. To understand why so many more days were needed to equate the CV measures, we need to examine which kinds of proxy counts worked best.

Not surprisingly, the best results were obtained at day-use developed sites whose counts were based directly on visitation. Ski areas that reported skier visits had essentially zero variance, since the counts needed no conversion to visits. These were especially important in reducing overall variance, because of the high volume of visits that occur there. Other developed sites that charge per-person fees did almost as well. There were a few instances where the one-to-one relation did not hold. Individual or vehicular traffic counts, such as turnstiles at visitor centers or pneumatic tubes at picnic area entrances had to be adjusted for return entrants on the same visit, or people who entered to just use the bathrooms.

Proxy counts for use of overnight developed sites with homogenous user patterns also had low CV estimates. Regardless whether the proxy was number of campsite-nights occupied or number of fee envelopes collected, if the campground was composed of just family-sized sites, the variability was lower than for overnight sites without proxy information. The gains in sampling were relatively greater on forests that had a large number of campgrounds, where the campgrounds are heavily used, or where the campgrounds are large – then the benefit of measuring a high visitor volume outweighs the variability.

Permanent traffic counters, especially those placed on roads that provide access to the general forest performed worst. Forest roads are used by commuters, loggers, agency staff, and others on non-recreation trips. The percentage of vehicles on non-recreation purposes can vary widely by season and day of the week. Variability was very high for ski areas that reported ticket sales, rather than skier visits. In general, vehicle-based counts had higher variance than counts based on number of sites used or number of people.

There were other reasons to use the proxy data as well. Personnel costs for sample days were reduced. Setting up the 24-hour traffic counter required at least two trips to the interview site, three if the interview period was neither at the beginning

or end of the 24-hour period. Travel from staff offices to interview sites often took several hours. Because 24-hour traffic counts were not needed for proxy sites, forest staff made at least one less trip per interview day. Some of this savings was offset by the staff time needed to collate and verify the annual counts from the various proxy sites.

Perhaps a more important benefit of using the proxy data is that it provides a means by which national forests can inexpensively estimate visitation in non-sample years. First, the forest must obtain the appropriate counts for proxy sites in the off-years. If we assume the forest-wide relationship between the proxy count and the associated visitation is nearly constant between survey cycles, the same calibration coefficients can be used to approximate visitation in the off years. Summing over all proxy sites and types gives a new estimate of proxy site visitation. We can further assume that the forest-wide ratio of proxy site visits to total visits is constant over the same time. Thus, if we apply the ratio of total visits to proxy site visits from the sample year to the off-year estimate of proxy visitation, we get an estimate of total visitation in the off-year.

Clearly using this type of information has the potential to dramatically affect the sample size needed to accurately estimate visitation. However, before using visitor proxy information in that fashion, researchers and managers need to consider certain issues carefully:

(1) How close is the proxy count to the measure of visitation desired? What other pieces of information are needed to convert the proxy counts into actual visit estimates? How will that information be elicited and how accurate and/or variable will those be?

(2) Does the visitation proxy account for all use of the site? If not, how can an accurate measure of its proportion be obtained?

(3) The research process presumes that the proxy count is an actual count, and known without error. Can the visitation proxy actually and accurately really be obtained from field staff? Can the count be verified readily?

(4) Are there other uses of the proxy counts, such as approximating visitation in subsequent years that make employing those counts feasible?

The answers to these questions can determine whether or not it is worth using visitation proxy data.