Appalachian National Scenic Trail Pilot Survey

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Abstract

Visitation statistics on the Appalachian National Scenic Trail are important for management and federal government reporting purposes. However, no survey methodology has been developed to obtain accurate trail-wide estimates over linear trails that traverse many hundreds of backcountry miles. This research develops a stratified random survey design which utilizes two survey instruments, exit site tallies, and a survey questionnaire to obtain visitation estimates on a portion of the AT. The design identifies three components (nonproxy, proxy, and Special Days) which can be used to subdivide the sampling frame into estimator types that lead to more efficient sampling and estimation processes. In addition, design-based and model-assisted approaches are used to obtain estimates for comparison purposes.

The survey was performed from June 1 through August 14, 2007, on a 109-mile stretch of the AT from Harpers Ferry, WV, to ten trail miles north of Boiling Springs, PA at the Scott Farm. Visitation estimates were 66,967 for the design-based approach and 70,912 for the model-assisted approach, with coefficients of variation of 23% and 16%, respectively. Individual strata level visitation estimates were quite variable and differed substantially between the two approaches.

An extrapolation to the entire trail for the whole year was performed by developing an appropriate sampling frame from which the strata weights could be obtained. Based on the model-assisted approach and assuming the Survey data were representative, the 2007 annual visitation extrapolation for the entire trail was 1,948,701 with a coefficient of variation of 20%.

Keywords: recreation trail use estimation; Lincoln-Petersen estimator; mark-recapture estimator; design-based estimator; model-assisted estimator.

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Introduction

The Appalachian National Scenic Trail (AT[1]) is a continuous marked footpath extending more than 2,175 miles across the Appalachian Mountains from the summit of Mount Katahdin in Maine to the summit of Springer Mountain in Georgia (fig. 1). It forms a greenway that connects more than 75 public land areas in 14 states. The AT was conceived in 1921, completed in 1937, and established as the first National Scenic Trail by Congress with the passage of the National Trails System Act in 1968 (Appalachian Trail Conservancy 2009). Consisting of over 250,000 acres that were acquired by the National Park Service (NPS) and the US Forest Service (USFS), it is a component of the National Trails System and a unit of the National Park System.

Information on AT visitor use is important to help agency managers and planners identify where resources and funds should be utilized. In addition, the data serves as a valuable component of the NPS Public Use Data Collecting and Reporting Program whose objectives are (1) to design a statistically valid, reliable, and uniform method of collecting and reporting public use data for each independent unit administered by the NPS, (2) to enact a variety of quality control checks to eliminate errors, (3) to provide analysis and verify measurements of the public use data, (4) to assure consistency of data collection within units of the NPS and (5) to support the continuous collection and timely publication of public use data (National Park Service 2009a). Moreover, information is required so that each park unit can report annually on Service-wide and park goals. For instance, the NPS Government Performance Results Act goal examines visitor safety incidents in terms of 100,000 visitor-days. However, lacking a visitation survey, the AT administrators can not accurately report to this important national objective.

[1] A list of acronyms and abbreviations is available at the end of this document

Despite the need for such AT visitation information, a statistically valid, reliable, and uniform method of collecting and reporting public use data for any of the national trails has never been developed. Individual park and forest units, along with researchers, have collected some data on AT hikers and backcountry users, particularly about user characteristics, attitudes, and preferences (Kyle, Graefe, Manning, and Bacon 2004; Manning and others 2000). In addition, use has been statistically estimated on some smaller trails which intersect the AT, like the Virginia Creeper Trail (Bowker, Bergstrom, and Gill 2004, 2007). However, there has never been a trail-wide study of AT visitation. Several years ago the Appalachian Trail Conservancy (ATC) produced an estimate of two to three million annual visitors on the AT. More recently, the NPS (2009b) and the Appalachian Trail Conservancy (ATC) (2009) report on their websites that estimated annual visits number between three and four million. Unfortunately, documentation on the estimation methodology is not available and visitation was not categorized into day use, overnight use, non-recreational use, or related categories. The ATC website also reports that thru-hikers have increased steadily over the past five decades, but have declined annually in number from 625 to 500 between 2001 and 2007. While the information on thru-hikers is likely accurate, they comprise an important but very small portion of overall AT use.

The main objective of this study was to develop a Pilot Survey design for estimating AT visitation that can be used as a prototype for future estimates of visitation on the entire AT. The survey design and estimates would also provide measures of precision such as standard errors and confidence interval estimates. In addition, this would provide the basis for a survey design applicable to some or all of the other components of the National Trails System. A secondary

objective was to use data from the Pilot Survey to develop a Trail-wide Extrapolation (TWE) estimate that would provide a visitation estimate for the entire AT. Because of limited resources, the Pilot Survey was designed to collect data during a limited time (June to August) and spatial (109 miles) segment of the AT. Thus, any extrapolation to the entire AT had to rely upon several assumptions. A final objective of the overall study was to design a survey based on information from the Pilot Survey which would include the approximate cost and effort required to conduct a statistically rigorous future survey of the entire AT. Sampling variability, logistical considerations and operational constraints obtained in carrying out the Pilot Survey were to be incorporated into this future survey design.

Part I – The Pilot Survey

Overview

The objective of the Pilot Survey emphasized the methodological development of an efficient sampling strategy for estimating recreation visitation on a linear hiking trail. Although it was important to obtain a good estimate of visitation for the survey, this was not the most important issue. A small pilot survey is often used as a precursor to a larger, more complete and complex survey in order to gather experience and necessary information about the sampling problems that are encountered while designing and implementing the survey. Completion of a pilot survey typically exposes unforeseen technical, logistical, and methodological problems, thus facilitating increased efficiency in a subsequent larger survey.

The Pilot Survey was applied to a 109-mile section of the AT extending from Harpers Ferry, WV to ten trail miles north of Boiling Springs, PA at the Scott Farm from June 1 through August 14,

2007 (fig. 2). This section provided a complex yet representative snapshot of the AT because it traversed multiple states and natural resource areas, intersected other low-use and high-use outdoor recreation sites, and was within easy traveling distance of major metropolitan areas. In addition, it was convenient to offices of study cooperators (NPS, ATC) and had a history of strong local club affiliations that would be beneficial when recruiting volunteers to assist with the field survey. The time period for the survey was selected to coincide with a period of expected high AT visitation which would provide maximum survey data for analysis, expose any unforeseen survey problems that needed to be addressed in future surveys, and coincide best with recruiting volunteers to administer the field survey. Information obtained from the Pilot Survey was later used to satisfy other objectives which included completion of the TWE to the entire AT by using appropriate strata weights and a preliminary design of a total AT survey.

The approach for the Pilot Survey uses on-site sampling of exit sites to obtain average daily estimates of the number of last-exiting recreationists (LERs) which are then expanded to the total annual visitation estimate. The methodology is based upon the concept that if all exit sites are identified and the number of LERs is counted for each day of the survey period, the sum will be the total visitation for that time period. The Pilot Survey design was based in part on the US Forest Service National Visitor Use Monitoring (NVUM) program that has been developed to obtain visitation estimates for the National Forests across the U.S. (English, Kocis, Zarnoch, and Arnold 2002; White, Zarnoch, and English 2007; Zarnoch, Kocis, Cordell, and English 2002).

Some trail use studies have incorporated a stratified random sampling design based on trail segments rather than exit sites wherein trail users were counted as they passed using either visual

or electronic means (Lindsey and Lindsey 2004; Stynes 1996; Wolter and Lindsey 2001). However, by counting LERs, we ensure that only recreationists will be included in the visitation estimate and that recreationists will not be "double counted" because they are exiting the site for the last time and, hence, will not return and exit to be counted again. An alternative approach that should give similar visitation estimates is to count only first-entering recreationists. However, other information such as length of stay, satisfaction with the facilities, etc., was also desired from the AT survey and obviously could not be obtained from first-entering recreationists.

The true visitation can only be obtained by counting all LERs from all exiting sites on all days throughout the survey period. This would be a complete census (Jacobi 2003) and, although it gives the correct visitation, a census would be cost prohibitive to administer over virtually all dispersed recreation areas and back country trails, especially for a long trail like the AT. Thus, a sampling approach that would be more feasible was used to obtain an estimate of visitation along with the standard error (SE) and confidence intervals (CI).

The AT Pilot Survey was based on a stratified random sampling design (Cochran 1977) subsequently adapted to trail, wildland, and other recreation use estimation (James and Schreuder 1971; Bergstrom, Teasley, Cordell, Souter, and English 1996; Gregoire and Buhyoff 1999; English, Kocis, Zarnoch, and Arnold 2002; Bowker, Bergstrom, and Gill 2004). The sampling frame consisted of the population of all possible recreation site days; a collection of all days at exiting sites that were open for recreation along the Pilot Survey area. These site days were then placed in fifteen potential strata consisting of five site-types and three use-levels. Within each stratum, a random sample of site days was selected which was visited by personnel who

administered the on-site field survey. The main benefit of stratification was to reduce the standard error of the visitation estimate. Stratification also allowed a more controlled allocation of the sample throughout the population of site days and provided separate visitation estimates for each stratum which may be of interest for addressing various management issues.

Sampling Design

Sampling frame—The first step in the Pilot Survey, called prework, developed the sampling frame consisting of all site days along the AT from Harpers Ferry, WV to ten trail miles north of Boiling Springs, PA at the Scott Farm from June 1 through August 14, 2007. A site day was defined as any day that a given site was available for LERs to be exiting. The formation of the population of site days required the identification of all exit sites along the Pilot Survey area of the AT, i.e., where a recreationist would possibly exit the AT, though not cross-country. This was accomplished by using a combination of resources including GIS data, trail maps, and guide books as well as interaction with AT personnel and other people knowledgeable about the trail. Table 1 lists all 120 exit sites defined in the Pilot Survey area, giving their assigned site numbers, site names and site-types (explained later). All sites were open for visitation during the Pilot Survey and, thus, each contributed 75 site days to the sampling frame implying a total of approximately 9,000 site days.

The development of strata was based on site-type and use-level applied to each site day. The objective was to formulate strata such that all site days within a given stratum were as uniform as possible with regard to AT visitation. Generally, when this is accomplished successfully in a stratified random sampling design, the average visitation between all the strata will be as

different as possible and the variation within each stratum will be as small as possible (Cochran 1977). This ideal situation is never met in practice, but if reasonably approximated, significant gains in precision of the visitation estimate are possible, resulting in smaller standard errors and narrower confidence intervals.

After reviewing the sites identified along both the Pilot Region and the whole AT, various patterns emerged that allowed the creation of several site-types. An exit site that simply consisted of a trail or road intersection across the AT was considered the Trail/Road (TR) site-type. If a parking lot was in the vicinity, as happened frequently where the AT intersected paved roads, then the site was a Parking (P) site-type. It was presumed that both of these site-types would exhibit almost exclusive use by AT recreationists. In other areas there was a complex network of sites, some not clearly defined, with potential for considerable non-AT use. Examples of such included state parks through which the AT traveled for a considerable distance. These site-types were called Multiple Use (MU). There were also several AT sites identified that intersected Harpers Ferry, WV, a unique town and historical National Park, which required the creation of a special site-type (HF). Here the overall AT and non-AT use were high and the intersection of the AT with the town was extremely complex (fig. 3) which did not resemble any of the other strata. The last site-type (ATCH) was unique to the Pilot Survey and consisted of the Headquarters Office of the Appalachian Trail Conservancy in Harpers Ferry, WV.

To further improve the stratification, the site days in each site-type were classified into one of three use-levels. These were Low (L), Medium (M) and High (H) depending on the anticipated number of LERs exiting from the site on the specific day**.** Note that this was based on the

number of recreationists who were last exiting, not simply all exiting people, or people who were either passing through the site, or beginning an AT visit at the site. Also, these use-levels were specific to a given site-type. Thus, use-level L for site-type TR was different than use-level L for site-type MU. A simplified manner of referring to a given stratum is to combine the site-type and use-level. For instance, the stratum site-type TR and use-level L will be hereafter referred to as simply stratum TR-L.

Stratification was formed by the classification of all site days into the 15 potential strata formed by the combination of the five site-types and three use-levels. For the Pilot Survey, there were no site days in the TR-H or ATCH-L strata, thus resulting in coverage of only thirteen strata.

While performing the very time consuming stratification of the site days with assistance from the ATC and local trail club staffs, it became evident that certain site days may have extremely high visitation due to special events in the vicinity. These were termed Special Days, and were initially removed from the sampling frame. Here visitation was estimated in a different manner and added to the final visitation estimate. The only Special Day for the Pilot Survey was June 2, 2007 at Boiling Springs, PA which was locally known as Foundry Day. The Pilot Survey sampling frame, thus, consisted of all site days for all the site-types (TR, P, MU, HF and ATCH) from Harpers Ferry, WV to ten trail miles north of Boiling Springs, PA at the Scott Farm during June 1 to August 14.

The well-known Mather Side Trail at Harpers Ferry, WV was initially included in the sampling frame, but was later deleted for several reasons. First, it did not seem to fit into one of the five

site-types previously defined. Although it most closely resembled site-type TR, it was felt that the proportion of LERs would be lower than the typical TR because it may contain a high proportion of non-AT visitation from Harpers Ferry, WV. This would then bias the visitation estimate for the TR strata if the Mather Side Trail was included in the site-type TR. Second, double counting may result because many people from the Mather Side Trail also visit, and would thus be counted at the ATCH site-type. Thirdly, The ATCH site-type had counts for practically the entire year from an auxiliary source which would be more useful than counts from a sample of the Mather Side Trail site days. Thus, the Mather Side Trail will not be discussed or included in any tables, figures and analyses in the rest of this report. In addition, the Special Day on June 2 at Boiling Springs, PA was excluded because it was surveyed in a different manner and included five site days, i.e., all five exit sites within Boiling Springs on June 2. Thus, the total Pilot Survey sampling frame consisted of 8995 site days distributed by site-type and use-level as shown in table 2. The TR-L strata had the most site days, totaling 40 percent of the entire sampling frame. The next largest were P-L with 20 percent and MU-L with 13 percent. Although these strata may represent low exit volumes and thus low levels of daily visitation, they comprise 73 percent of all site days and, therefore, may have a large impact on the visitation estimate.

Nonproxy and proxy sites—The sites identified on the AT are classified as either nonproxy or proxy. The nonproxy sites are those where no information about recreation visitation is available from any sources except the Pilot Survey itself. In contrast, proxy sites are those where information is available from an auxiliary source that could be used, alone or in conjunction with other information, to derive an estimate of recreation visitation. For example, one might have

monthly traffic counts, but would need information on the percentage of vehicles that contained LERs and the average number of people per vehicle to arrive at an estimate of recreation visits. The Pilot Survey designated all TR, P and MU site-types as nonproxy and the HF and ATCH site-types as proxy.

Generally, it is beneficial to have as many proxy sites as possible because it can increase the efficiency of the survey when using supplemental information collected by other sources. This results in cost savings which allows additional sampling to be allocated to the nonproxy sites, thus, increasing the sample size and reducing variability. In addition, the variances of the estimates associated with proxy sites where data collection is usually more intensive and better controlled are often much less than that of the nonproxy sites, so the quality of the visitation estimates that include proxy sites is further improved.

Although proxy sites can be very advantageous, they may present a few difficulties. First, the identification of proxy sites may be difficult and often requires extensive interaction with field personnel who are familiar with the sites and know which management activities are being performed that may enable the site to be a proxy. Second, the concept of a proxy is often a vague and abstract concept that must be understood in order to optimally identify appropriate proxy sites. Third, individual proxy sites may require unique methods of estimation that add complexity to the sampling methodology. Despite these problems, the use of proxy sites has been found to be worth the additional effort in terms of cost savings and variance reduction (English and others 2003).

Prework spreadsheets—The creation of the sampling frame and strata required the identification and strata characterization of all sites along the entire AT. This was initially performed for the Pilot Survey area and subsequently completed for the rest of the MidAtlantic Region, along with the New England, Virginia and Southern Regions. Beginning with Springer Mountain, GA, and continuing to Mount Katahdin, ME, all sites were given a site number, a site name, and assigned a site-type. Overall, a total of 953 "unique" exit sites were identified with 849 being open the entire year.

The formulation of the sampling frame was a vital component of the Pilot Survey and was dependent on the prework spreadsheets. Data entry consisted of identifying one to several date spans (begin and end) for a given site such that the specified days of the week all had the same use-level as assigned to that date span. A "1" was entered for a day of the week if it had that use-level in the date span and a blank if not. If a holiday had the same use-level, then a "1" was also entered, if not, then a blank (detailed examples follow in the next paragraph). Five recognized holidays were presumed to affect AT visitation -- Memorial Day, Independence Day, Labor Day, Columbus Day and Thanksgiving. Although others like Christmas and New Years may attract increased visitation to the AT by some avid hikers, it was felt that due to possible adverse weather conditions and other social and cultural activities, their impact on AT visitation would not merit Holiday status.

Many sites had a simple use patterns. For example, at site number 809 all days of the year were use-level L, so only one date span was needed with "1' for all days of the week and the holiday (Appendix 1). However, others sites had more complex patterns of use-levels. For instance, site

number 810 required 7 date spans to represent its use-levels. This site had one date span for the time period January 2, 2007 (102) to December 24, 2007 (1224) to represent use-level L for all five weekdays. However, two additional date spans were needed for the weekends from January 2, 2007 (102) to March 31, 2007 (331) and November 1, 2007 (1101) to December 24, 2007 (1224) where use-level was M. In addition, January 1, 2007 (101) was considered use-level H, so a separate date span had to be created because this was not one of the specified five holidays. The date span from April 1, 2007 (401) to October 31, 2007 (1031) was specified use-level H for only the weekends, but for December 25, 2007 (1225) to December 31, 2007 (1231) use-level H was given to all days of the week. All five holidays were considered use-level H and, thus, given the date span 101 to 1231 with "1' for holiday only. Note that each holiday could have been specified individually or possibly specified in a previous date span, but for this situation it was simply easier to "bundle" them under one date span. Thus, there are many ways in which the use-levels could be specified for a given site which led to identical classifications for all days of the year.

Although the method presented for site classification may appear confusing at first, once grasped it is simple and efficient for data entry and analysis. To ensure data quality, edit checks were performed to verify that a given site had at most one use-level for a given day and at most only 365 days open for recreation with use-level L, M, or H. Such errors are common, especially for those entering data using this method for the first time. The number of sites identified for each of the regions was New England=239, Mid Atlantic (excluding Pilot) =319, Pilot=120, Virginia=146 and Southern=129, for a total of 953. The Mather Side Trail site is not included. The percent of sites open every day of the calendar year for each of the regions was: New

England=67%, MidAtlantic (excluding Pilot) =98%, Pilot=99%, Virginia=100% and Southern=86%, with the overall weighted average being 89%.

The creation of the prework spreadsheet for the site type ATCH was based on the proxy data obtained from the ATC Headquarters Office in Harpers Ferry, WV. According to personnel at the ATCH, their daily tally data consisted of one tally only for each person who came into the ATCH, so multiple enters/exits by the same individual were eliminated. The ATCH staff was obviously not included in the daily tallies. However, a delivery person who showed interest in the AT or asked questions may be included. Months were characterized based on their monthly average visitor tallies with use-level L being less than 20, M being 20 to 60 and H being greater than 60. In certain months, the weekends had significantly higher visitation than their monthly average and, thus, were classified into the next higher use-level. This resulted in January 1, 2007 through March 30, 2007 being use-level L. The period from March 31, 2007 through April 30, 2007 was M on weekdays and H on weekends. All of May 2007 was M on weekdays and H on weekends and Memorial Day. Both June 2007 and July 2007 were H all month while August 2007 and September 2007 were M all month. October 2007 was M on weekdays and H on weekends. November 2007 was M all month while December 2007 was L all month. Appendix 1 illustrates these data in prework spreadsheet format.

Sample selection—The sampling frame for the Pilot Survey consisted of 8,995 site days from which 146 sample days were selected randomly within the specified strata according to the sample allocation shown in table 2. Although proportional allocation (Cochran 1977) could have been used to determine the number of site days to sample per stratum, a more efficient method is

Neyman (optimal) allocation which selects more site days from the strata that are larger and/or more variable (Cochran 1977). The prework that was done for the creation of the sampling frame provided the information on strata size (table 2). However, although a measure of absolute variability was not known, a relative measure was believed to be positively correlated with use-level, which was found true after sampling was completed. Thus, using the Neyman allocation approach an allocation pattern was created as shown in table 2.

The allocation for the Pilot Survey relied upon researcher judgment for the optimal way to use the limited labor and financial resources of 146 sample days and thus did not strictly follow Neyman allocation. The approach, again requiring considerable researcher judgment, was to get the best coverage possible while adhering to the Neyman allocation principles of strata size and variability. All TR site days in all use-levels were believed to have very low visitation and, thus, low variability so all use-levels were assigned 10 site days which was considered the minimum acceptable sample size. The P and MU site days had the opportunity for higher visitation and higher variability, especially for use-levels M and H, so 10, 15 and 25 were allocated to their L, M and H use-level strata, respectively. Although visitation on the HF site days was anticipated to be very high, there were relatively few site days in these strata, so following the Neyman allocation principles 4, 5, and 11 were assigned to the L, M and H use-levels, respectively. Note that this is less than the minimum of 10 due to the limited resources issue and the low strata sample size. The ATCH site consisted of a total of only 75 site days so only 2 and 4 site days were assigned to M and H, respectively.

The survey design was based on a six hour interviewing period for each selected sample site day. Bowker, Bergstrom, and Gill (2004) used four or eight hour periods depending on time of year. The Forest Service uses six hour periods for NVUM (English, Kocis, Zarnoch, and Arnold 2002; Zarnoch, Kocis, Cordell, and English 2002). This six hour sampling period for the TR, P, MU and HF site types was allocated randomly with one third in the AM and two thirds in the PM. This disproportionate sampling allocation was used to get a better estimate during the afternoon hours when exiting visitation was believed to be higher and when there would be a greater potential to obtain more interviews and, hence, more survey information. The visitation estimate was weighted accordingly. he ATCH site-type was open for visitation from 9:00 am to 5:00 pm (4:00 pm on weekends), so the six hour sampling period was not assigned to an AM or PM category. The sampling calendar (table 3) was developed by randomly selecting the allocated sample size from each stratum by using a custom-designed computer program. Backup sampling days were generated in case the scheduled ones from the sample calendar could not be followed for a variety of reasons, which occasionally occurred as shown in table 3. The sample sizes that were actually achieved for the strata during the Pilot Survey, accounting for missing sample days and backup substitutes, are shown in table 2.

Characterization of the pilot survey sampling days— There were 146 sampling days scheduled for the Pilot Study, excluding the Special Day at Boiling Springs on June 2, 2007. The number of these actually sampled was 114 for a 78.1 % accomplishment rate. Of the 32 days that were assigned and missed, 12 were completed by using the correct backup days while two were completed with ad hoc backup days. In either case, all 14 were of the same site-type and use-level as that of the originally missed sample day, preserving as much as possible the original

sampling allocation. Of the 32 missed days, 18 were never replaced with backup days and, thus, the sample size was reduced from what was originally planned. Over the course of the survey, two extra sample days were taken; one was in stratum MU-H and the other P-L. Thus, the total number of sample days completed by field personnel was 146-18+2=130. This consisted of 51 different sites with each being sampled anywhere from 1 to 13 times over the course of the survey. Of this sample, 101 sample days resulted in at least one interview being obtained. Although on 29 sample days there were no people observed, and thus no interviews, these sample days still provided valuable data because they represented zero visitation.

The major reason for the missing sample days was limited resources available for field survey administration. The Pilot Study employed two full-time field surveyors and occasionally augmented them with two project surveyors (whose major responsibilities were other duties besides field surveying) and several volunteers. Many of the missed sample days were on days when the number of randomly selected sample days exceeded two and there were insufficient interviewers available to perform the surveys.

Survey procedures— The actual implementation of the survey began with assigning each sample day to a trained field survey interviewer who performed the survey. The procedure consisted of a six hour on-site tally of all people that were potential recreationists who appeared to be exiting the site. Obvious non-recreating people such as uniformed state and federal park personnel were not included in the survey tally. As mentioned previously, the survey was scheduled to be either AM (8:00 to 2:00) or PM (2:00 to 8:00) but minor departures from the specific times occurred and were recorded and adjusted for appropriately. At eight of the MU

sites exiting vehicles were tallied because the volume and nature of the exiting people were not conducive to a people tally.

In addition, survey interviews were conducted on a random sample of groups that were exiting. The person interviewed was selected randomly from each group by asking which group member, aged 16 or older, had the most recent birthday. The goal was to interview as many groups as possible. Thus, at the use-level L strata all groups may have been interviewed while at the use-level H strata the sampling fraction may have been much lower. The main objective of the questionnaire was to interview only people who appeared to be using the AT for recreation and were leaving the AT for the day at the time of the interview. Exceptions to the exiting criterion occurred at proxy sites like Harpers Ferry and the ATCH, where interviews were at random. All interviewees were screened out with a series of initial questions and then asked a another set of questions dealing with arrival time, hiking distance, frequency of previous visits, demographics and a few other trip attributes (fig. 4). In addition, other people who did not meet these criteria were also interviewed to a limited extent to gather other information needed for the survey estimation process. The exiting people tally during the interviewing period was recorded which provided information on the distribution of exiting people throughout the survey day. At the completion of a survey day, the interviewer filled out the Day Summary form (fig. 5) which contains information on the interview team, date and time of the survey, tally and number of completed interviews.

Estimation Methodology

Statistical background— The estimation methodology used to obtain estimates for the Pilot Survey requires a fundamental knowledge of several statistical concepts. The estimators for visitation are relatively straightforward, however, the computation of variances are usually not. In particular, the sampling design must be considered when computing variances of certain estimated calibrating parameters and quantities. Moreover, visitation estimators often consist of the product or ratio of other estimated variables and their variances are complex equations. A general introduction to these statistical issues (Cochran 1977) is presented here.

The Pilot Survey is a complex stratified cluster sampling design that must be considered when obtaining variances of estimated quantities. The primary sampling unit (PSU) is the site day within a stratum and the secondary sampling unit (SSU) is the group interviewed on a given site day. If X is a variable measured at the PSU level, then an estimator for the mean for a given stratum is the simple arithmetic mean

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \qquad (1)$$

where,

y_i = the observed variable on sample day i and

n = number of sample days.

An estimator for the variance (ignoring the finite population correction) is

$$\hat{V}\left(\bar{y}\right) = \frac{\sum_{i=1}^{n}\left(y_i - \bar{y}\right)^2}{n\left(n-1\right)} \qquad (2)$$

When quantities are estimated at the SSU level, the clustering of the data within a sample day must be considered. If this is not done and the observations are viewed as a simple random sample and equations (1) and (2) used, then variances will usually be underestimated, standard errors will be too small, confidence intervals will be too narrow and statistical tests will have inflated Type I error rates. In such a situation, the ratio of means estimator should be used for clustered data and is defined as

$$\hat{R} = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i} = \frac{\bar{y}}{\bar{x}} \tag{3}$$

where

y_i = the sum of the observed variable for all observations in cluster i,

x_i = the number of observations in cluster i and

n = number of clusters sampled.

The estimated variance (ignoring the finite population correction) is

$$\hat{V}\left(\hat{R}\right) = \frac{1}{n(n-1)(\bar{x})^2}\left(\sum_{i=1}^{n} y_i^2 + \hat{R}^2 \sum_{i=1}^{n} x_i^2 - 2\hat{R}\sum_{i=1}^{n} y_i x_i\right) \tag{4}$$

A couple general variance calculating methods are used quite often in the Pilot Survey. One is the variance of the product of a constant k and a variable. In this situation

$$\hat{Q}_1 = k\hat{x} \tag{5}$$

and the estimated variance is

$$\hat{V}\left(\hat{Q}_1\right) = k^2 \hat{V}\left(\hat{x}\right) \tag{6}$$

The other is the estimated variance of the sum of two independent estimates

$$\hat{Q}_2 = \hat{x} + \hat{y} \tag{7}$$

which is simply the sum of the estimated variances of each and is defined as

$$\hat{V}\left(\hat{Q}_2\right) = \hat{V}\left(\hat{x}\right) + \hat{V}\left(\hat{y}\right) \tag{8}$$

Another complexity that is often encountered is the estimated variance for an estimate that is a product of several other estimates that are independent. Let the estimate be defined as the product of two estimated independent quantities as

$$\hat{Q}_3 = \hat{x}\hat{y} \tag{9}$$

An estimate of the variance (Goodman 1960) is

$$\hat{V}\left(\hat{Q}_3\right) = \hat{x}^2\hat{V}\left(\hat{y}\right) + \hat{y}^2\hat{V}\left(\hat{x}\right) - \hat{V}\left(\hat{x}\right)\hat{V}\left(\hat{y}\right) \tag{10}$$

An extension to the product of three independent variables

$$\hat{Q}_4 = \hat{x}\hat{y}\hat{z} \tag{11}$$

is often needed and this could be derived as an extension of equation (10) as

$$\hat{\mathrm{V}}\left(\hat{\mathrm{Q}}_4\right) = \hat{x}^2\hat{y}^2\hat{V}\left(\hat{z}\right) + \hat{x}^2\hat{z}^2\hat{V}\left(\hat{y}\right) + \hat{y}^2\hat{z}^2\hat{V}\left(\hat{x}\right) - \hat{x}^2\hat{V}\left(\hat{y}\right)\hat{V}\left(\hat{z}\right) - \hat{y}^2\hat{V}\left(\hat{x}\right)\hat{V}\left(\hat{z}\right)$$
$$- \hat{z}^2\hat{V}\left(\hat{x}\right)\hat{V}\left(\hat{y}\right) + \hat{V}\left(\hat{x}\right)\hat{V}\left(\hat{y}\right)\hat{V}\left(\hat{z}\right) \tag{12}$$

Occasionally an estimator is the product of three independent variables, one of which is also a quotient of two independent variables where the denominator is correlated with one of the other product variables. This is an extremely complex situation. When this occurs in the Pilot Survey, the variance of the quotient variable is very small, thus it is assumed to be a constant with zero variance. This then reduces to the variance of a product of two variables as in equation (9) and, thus, the variance is estimated using a slight modification of equation (10).

Two approaches were used for estimating the various calibration parameters for the visitation estimators in the strata. The survey-based estimation approach is the traditional methodology where estimators are developed from the sample data from each stratum according to a cluster survey design as outlined in statistical references such as Cochran (1977). This is the optimal method provided sufficient sample data have been obtained. However, when resources are limited, as was the case in the Pilot Survey, a model-assisted estimation approach may be more appropriate.

In the current study, a mixed linear model is developed by pooling the data from all the strata. The fixed components of the model are site-type and use-level. The interaction is assumed negligible and, thus, excluded from the model. The clustering of the observations within the sample days is addressed by treating them as repeated measures with the variance components covariance structure, implying a common variance and zero covariance for the observations within a cluster. The estimated parameters from the model are used to obtain the strata means and variances which reflect a smoother relationship than those from the survey-based approach. When sample size is small and the data is highly variable, this is an appealing property. The assumption of no interaction between site-type and use-level seems reasonable and is a necessary trade-off for the smoother relationship. When the assumption is not valid, then the survey-based approach may be more appropriate. If interaction effects are put into the model, then the estimates and variances should be very close to the survey-based approach.

Another advantage of the model-assisted approach is that it is possible to obtain estimates for strata that are not specifically represented in the sample data as long as their site-type and use-

level are represented in the data. In this situation the survey approach would have to use a more arbitrary method to obtain a pooled estimate. This is not a factor for the Pilot Survey because all 13 strata were all represented with data and both approaches may be used. However, the TWE required estimates for two strata that were not represented with the Pilot Survey data which gives additional support to using the model-assisted approach. Moreover, the model-assisted approach has the potential to yield smaller variances because the estimates are based on data from all strata and not just one stratum as in the survey-based approach. Thus, for these reasons, the Pilot Survey examined both approaches and after evaluation, used the model approach for the final estimates.

Pilot survey visitation estimator—Total visitation for the Pilot Survey from June 1 to August 14, 2007 is defined as

$$VISITS = NP + P + SD \quad (13)$$

where

$VISITS$ = the total number of recreation visits to the AT in the Pilot Study area from June 1 through August 14, 2007,

NP = the total number of AT nonproxy visits,

P = the total number of AT proxy visits and

SD = the total number of AT recreation visits from the Special Day sites at Boiling Springs, PA on June 2, 2007.

The determination of an LER was dependent on the site-type of the sample day. For site-types TR and P, any potential interviewee who refused to be interviewed was considered an LER. In contrast, for site-types MU, ATCH and HF, a refusal was simply considered a missing

observation. The rationale for this was that it was believed that refusals at site-types TR and P were most likely LERs because these site-types were generally in remote areas with few other activities besides hiking on the AT. However, at site-types MU, ATCH, and HF there was a much higher diversity of activities and the likelihood of being an LER or non-LER was indeterminate.

All three components are independent so the variance is

$$\hat{V}(VISITS) = \hat{V}\left(\hat{NP}\right) + \hat{V}\left(\hat{P}\right) + \hat{V}\left(\hat{SD}\right) \tag{14}$$

Each of the above three components requires a different estimation methodology which are now presented.

Nonproxy component—The nonproxy component consisted of all sites in the strata composed of the TR, P and MU site-types and all three use-levels L, M and H where they existed. The nonproxy component, which does not contain the TR-H stratum in the Pilot Survey, is estimated as

$$\hat{NP} = \sum_{h=1}^{8} N_h \overline{P}_h \overline{C}_h \overline{G}_h \tag{15}$$

with estimated variance

$$\begin{aligned}\hat{V}\left(\hat{NP}\right) = &\sum_{h=1}^{8} N_h^2 \left\{\overline{P}_h^2 \overline{C}_h^2 \hat{V}\left(\overline{G}_h\right) + \overline{P}_h^2 \overline{G}_h^2 \hat{V}\left(\overline{C}_h\right) + \overline{C}_h^2 \overline{G}_h^2 \hat{V}\left(\overline{P}_h\right)\right\} \\ &- \sum_{h=1}^{8} N_h^2 \left\{\overline{P}_h^2 \hat{V}\left(\overline{C}_h\right)\hat{V}\left(\overline{G}_h\right) + \overline{C}_h^2 \hat{V}\left(\overline{P}_h\right)\hat{V}\left(\overline{G}_h\right) + \overline{G}_h^2 \hat{V}\left(\overline{P}_h\right)\hat{V}\left(\overline{C}_h\right)\right\} \\ &+ \sum_{h=1}^{8} N_h^2 \hat{V}\left(\overline{P}_h\right)\hat{V}\left(\overline{C}_h\right)\hat{V}\left(\overline{G}_h\right)\end{aligned} \tag{16}$$

where

N_h = the total number of site days in stratum h,

$\overline{P}_h$ = the average proportion of exiting groups in stratum h that are LERs,

$\overline{C}_h$ = the average number of groups of people (recreating or not) counted as exiting in stratum h,

$\overline{G}_h$ = the average size of the LER group in stratum h

and $\hat{V}(\overline{P}_h)$,$\hat{V}(\overline{C}_h)$, and $\hat{V}(\overline{G}_h)$ are the estimated variances of $\overline{P}_h$, $\overline{C}_h$, and $\overline{G}_h$, respectively. Note that the index of summation does not include strata TR-H because it does not exist in the Pilot Survey and, thus, there are only eight strata.

To get an estimate for equation (15), each of the four components must be obtained and multiplied. The N_h are known constants and are obtained from the prework spreadsheet data (table 2) while the $\overline{P}_h$, $\overline{C}_h$, and $\overline{G}_h$ are estimated from the interview survey data. Let

n_h = the number of sample days in stratum h,

m_{hi} = number of groups interviewed on sample day i in stratum h,

p_{hij} =1 if group j on sample day i in stratum h was an LER

= 0 elsewhere,

Moreover, there are two types of groups that are recognized in the interview process; those that are LER and those that are not. Thus, let

g_{hij} = the number of people in interview group j on sample day i in stratum h for an LER group and

g_{hij}^{a} = the number of people in interview group j on sample day i in stratum h for any type of group (the superscript "a" refers to "all" groups).

Also, there are two types of site days; those which tally people and those which tally vehicles. Let

c_{hi}^{p} = the number of people tallied exiting the AT from sample day i in stratum h during the six hour interview period and

c_{hi}^{v} = the number of vehicles tallied exiting the AT from sample day i in stratum h during the six hour interview period.

The survey data can be used to obtain a ratio of means estimator for $\overline{P}_h$ defined as

$$\overline{P}_h = \frac{\sum_{i=1}^{n_h}\sum_{j=1}^{m_{hi}} p_{hij}}{\sum_{i=1}^{n_h} m_{hi}} \qquad (17)$$

with estimated variance

$$\hat{V}\left(\overline{P}_h\right) = \frac{1}{n_h\left(n_h-1\right)\left(\frac{1}{n_h}\sum_{i=1}^{n_h} m_{hi}\right)^2}\left\{\sum_{i=1}^{n_h}\left(\sum_{j=1}^{m_{hi}} p_{hij}\right)^2 + \overline{P}_h^{\,2}\sum_{i=1}^{n_h} m_{hi}^2 - 2\overline{P}_h^{\,2}\sum_{i=1}^{n_h}\left(m_{hi}\sum_{j=1}^{m_{hi}} p_{hij}\right)\right\} \qquad (18)$$

This estimator considers the clustering of the data on a site day basis. The estimators given in equations (17) and (18) are valid when the number of sample days in a stratum is evenly distributed in the AM and PM categories. However, as the sample allocation was 1/3 AM and 2/3 PM, an appropriate weighting scheme was used. In addition, missed sampling days and sample days without interviews (and no p_{hij}) further distorts the designed allocation. Thus, the weights used for a given stratum were obtained as the proportion of sample days containing at least one

p_{hij} that were AM and PM. For instance, in stratum P-H the original allocation was AM=9 and PM=16 but the achieved was AM=8 and PM=12 with the number of sample days with at least one p_{hij} being AM=7 and PM=11. Thus, the weights used for stratum P-H were AM=7/18=0.39 and PM=11/18=0.61. The analytical equations based on these weights are quite complicated and will not be presented here. Practical calculation of these estimators was easily performed for the survey-based and model-assisted approaches by using PROC SURVEYMEANS and PROC MIXED (SAS Institute Inc. 2004), respectively.

To obtain the average daily tally $\overline{C}_h$, the arithmetic mean is used because the daily count data are not clustered. Thus, when the sample day is a vehicle tally,

$$\overline{C}_h = \frac{\sum_{i=1}^{n_h} 2c_{hi}^{v}}{n_h} \tag{19}$$

with variance

$$\hat{V}\left(\overline{C}_h\right) = \frac{4\sum_{i=1}^{n_h}\left(c_{hi}^{v} - \overline{c}_h^{v}\right)^2}{n_h\left(n_h - 1\right)} \tag{20}$$

The estimators shown in equations (19) and (20) are valid when the number of sample days in a stratum is evenly distributed in the AM and PM categories. This was not the case in the Pilot Survey, so separate estimates for a stratum were computed for AM and PM using equations (19) and (20). The AM and PM were then combined by simply averaging which achieved the appropriate weighting and the variance was computed in the typical manner.

The constant ‘2’ in equation (19) expands the six hour tally to a 12-hour recreation day. Note that for the TWE no adjustment is used to calibrate the recreation day to a shorter length during the winter months. This is because the use-level for a site was defined on a day basis. However, if the use-level was on a density per hour basis then a day length adjustment would be needed.

Recall that at a specific site either people or vehicles may be tallied as outlined in the sampling protocol. Although only eight sites are vehicle tally sites and the others are people tally sites, the survey is based on interviewing groups and, thus, vehicle tallies are the appropriate unit. This is because the group is the sampling unit for the interviews but the tally of groups may be impossible to accurately obtain if non-interviewed groups that pass the survey spot are attempted to be tallied. For vehicle sites the group is easily tallied because it is contained in a vehicle. At people sites exiting groups of people may mix together causing tally problems. Therefore, it is imperative to convert all people tally sample days to vehicle tally days before using the estimator (19) and its variance (20). This conversion is defined as

$$c_{hi}^{v} = \frac{c_{hi}^{p}}{\sum_{j=1}^{m_{hi}} \frac{g_{hij}^{a}}{m_{hi}}} \qquad (21)$$

In addition, note that the denominator in equation (21) is the average group size for all exiting groups for a specific day i in stratum h, which is used to convert the people count c_{hi}^{p} to a vehicle count c_{hi}^{v}. This is performed on a sample day basis and yields the variable c_{hi}^{v} directly from which the stratum mean and variance could be easily obtained using equations (1) and (2), respectively. This is preferred to using the average exiting all group size for the entire stratum in

the denominator of equation (21) in which case the variable c_{hi}^{v} would be a ratio of two variables. To obtain the variance of such a variable would require a more complicated equation that would include the covariance of the numerator and denominator.

To obtain an estimator for group size, the ratio of means must again be used for clustered data, yielding

$$\overline{G}_h = \frac{\sum_{i=1}^{n_h}\sum_{j=1}^{m_{hi}} g_{hij}}{\sum_{i=1}^{n_h} m_{hi}} \qquad (22)$$

with estimated variance

$$\hat{V}\left(\overline{G}_h\right) = \frac{1}{n_h\left(n_h-1\right)\left(\frac{1}{n_h}\sum_{i=1}^{n_h} m_{hi}\right)^2}\left\{\sum_{i=1}^{n_h}\left(\sum_{j=1}^{m_{hi}} g_{hij}\right)^2 + \overline{G_h}^2\sum_{i=1}^{n_h} m_{hi}^2 - 2\overline{G_h}^2\sum_{i=1}^{n_h}\left(m_{hi}\sum_{j=1}^{m_{hi}} g_{hij}\right)\right\} \qquad (23)$$

The estimators shown in equations (22) and (23) are valid when the number of sample days in a stratum is evenly distributed between the AM and PM categories. However, as mentioned previously, the sample allocation was 1/3 AM and 2/3 PM and this has to be taken into account by appropriate weighting in the estimation process. In addition, missed sampling days and sample days without interviews (and no g_{hij}) further distorts the designed allocation. Thus, the weights used for a given stratum were obtained as the proportion of sample days containing at least one g_{hij} that were AM and PM. Thus, the weighting methodology described for $\overline{P}_h$ was also used here.

The nonproxy estimator equation (15) is obtained by substituting the quantities for N_h, $\overline{P_h}$, from equation (17), $\overline{C_h}$ from equation (19) and $\overline{G_h}$ from equation (22) into equation (15). The estimated variance is found by substituting the corresponding variances from equations (18), (20), and (23) into equation (16).

Proxy component—*Site-type ATCH*—The site-type ATCH proxy data consisted of 75 daily visitor tallies at the ATC Headquarters Office in Harpers Ferry, WV obtained from June 1 through August 14, 2007. This was combined with the estimates $\overline{P_h}$ and $\overline{G_h}$ obtained from the six sample site days taken during the Pilot Survey at the ATCH. The ATCH was open for eight hours during the week and seven hours on weekends which was considered the entire day with respect to last exiting recreationists. Thus, no adjustment for day length of seven or eight hours or expansion to a 12 hour day was used.

The visitation estimate for the ATCH for the Pilot Survey is as follows. Let

N_h = total number of days that the ATCH has days in use-level h, $(h = M, H)$, during the Pilot Survey,

n_h = number of days the ATCH tallied visitors for stratum h during the Pilot Survey,

$PROXY_{hi}^{ATC}$ = the ATCH visitor tally on day i in use-level h

then, the average daily proxy visitation tally in use-level h is the arithmetic mean

$$\overline{PROXY_h^{ATCH}} = \frac{\sum_{i=1}^{n_h} PROXY_{hi}^{ATCH}}{n_h} \qquad (24)$$

with estimated variance

$$\hat{V}\left(\overline{PROXY_h^{ATCH}}\right)=\left(1-\frac{n_h}{N_h}\right)\frac{\sum_{i=1}^{n_h}\left(PROXY_{hi}^{ATCH}-\overline{PROXY_h^{ATCH}}\right)^2}{n_h\left(n_h-1\right)}=0 \qquad (25)$$

Note that all 75 days were tallied and, thus, $N_h = n_h = 75$ and consequently the finite population correction is zero which results in the variance being equal to zero.

The visitation estimate for the ATCH for the Pilot Survey is defined as

$$PROXY^{ATCH}=\sum_{h=M}^{H}N_h\overline{P}_h\left(\frac{\overline{PROXY_h^{ATCH}}}{\overline{G_h^a}}\right)\overline{G}_h \qquad (26)$$

where

$PROXY^{ATCH}$ = total visitation estimate for the ATCH for the Pilot Survey,

$\overline{P_h}$ = the proportion of groups exiting the ATCH that are AT LER,

$\overline{G_h^a}$ = the average group size for all groups exiting the ATCH,

$\overline{G_h}$ = the average group size for all AT LER groups exiting the ATCH.

The $\overline{P_h}$ and $\overline{G_h}$ and are estimated as described previously in equations (17) and (22) and $\overline{G_h^a}$ is estimated in a similar ratio of means manner as

$$\overline{G_h^a}=\frac{\sum_{i=1}^{n_h}\sum_{j=1}^{m_{hi}}g_{hij}^a}{\sum_{i=1}^{n_h}m_{hi}} \qquad (27)$$

with estimated variance

$$\hat{V}\left(\overline{G_h^a}\right)=\frac{1}{n_h\left(n_h-1\right)\left(\frac{1}{n_h}\sum_{i=1}^{n_h}m_{hi}\right)^2}\left\{\sum_{i=1}^{n_h}\left(\sum_{j=1}^{m_{hi}}g_{hij}^a\right)^2+\overline{G}^2\sum_{i=1}^{n_h}m_{hi}^2-2\overline{G}\sum_{i=1}^{n_h}\left(m_{hi}\sum_{j=1}^{m_{hi}}g_{hij}^a\right)\right\} \qquad (28)$$

where

g_{hij}^{a} = the number of people in interview group j on sample day i in stratum h for any type of group and

m_{hi} = number of groups interviewed on sample day i in stratum h.

Note that in eqation (26) the summation is only over the use-levels M and H.

The estimators given in equations (27) and (28) are valid when the number of sample days in a stratum is evenly distributed in the AM and PM categories. However, as mentioned previously, the sample allocation was 1/3 AM and 2/3 PM and this has to be taken into account by appropriate weighting in the estimation process. In addition, missed sampling days and sample days without interviews (and no g_{hij}^{a}) further distorts the designed allocation. Thus, the weights used for a given stratum were obtained as the proportion of sample days containing at least one g_{hij}^{a} that were AM and PM. Thus, the weighting methodology described for $\overline{P}_h$ was also used here.

The variance of estimator (26) is quite complicated because it is a product of a constant and three variables as well as a ratio of a dependent variable. To simplify matters, assume that $\overline{G_h^a}$ is a constant, which is reasonable because its variance is quite small and it is highly correlated with $\overline{G_h}$. Then we have approximately

$$\hat{V}\left(PROXY^{ATCH}\right) = \sum_{h=M}^{H} N_h^2 \left(\frac{\overline{PROXY_h^{ATCH}}}{\overline{G_h^a}} \right)^2 \left\{ \overline{P}_h^2 \hat{V}\left(\overline{G}_h\right) + \overline{G}_h^2 \hat{V}\left(\overline{P}_h\right) - \hat{V}\left(\overline{P}_h\right)\hat{V}\left(\overline{G}_h\right) \right\} \qquad (29)$$

because $\hat{V}\left(\overline{PROXY_h^{ATCH}}\right) = 0$ as shown in equation (25) which drops four terms out of the general variance equation (12), simplifying the variance to a product of only two variables and two constants.

Proxy component— *Site-type HF*—The HF site-type consisted of the three sites located at Harpers Ferry (810, 811 and 813). Although these sites could have been sampled and visitation estimated similarly to the nonproxy sites, it was more advantageous to utilize the official monthly NPS recreation visitation for Harpers Ferry National Historical Park as proxy data[2] (National Park Service 2008). This provided visitation estimates based on data for the total 75 days at Harpers Ferry which was considered superior to just visitation estimates derived from the 20 site days that were planned to be sampled by the Pilot Study. In addition, it provided data for the entire year which was also advantageous for the TWE. However, there were several limitations to using this proxy data that had to be resolved. The reported NPS visitation included (a) both AT and non-AT visits, (b) was not stratified by use-level and (c) was only available on a monthly basis. To resolve these problems required a monthly $\overline{P_i}$ derived from weighting the individual three use-level estimates obtained from the Pilot Study for the site type HF by the monthly strata weights obtained from the prework spreadsheet data. The weighted $\overline{P_i}$ and variance were defined as

$$\overline{P_i} = \frac{N_{Li}\overline{P_L} + N_{Mi}\overline{P_M} + N_{Hi}\overline{P_H}}{N_{Li} + N_{Mi} + N_{Hi}} \qquad (30)$$

[2] Personal communication. September 10, 2008. Butch Street, Management Analyst, National Park Service Use Statistics Office, Denver, CO 80225.

$$\hat{V}\left(\overline{P_i}\right)=\frac{N_{Li}^2\hat{V}\left(\overline{P_L}\right)+N_{Mi}^2\hat{V}\left(\overline{P_M}\right)+N_{Hi}^2\hat{V}\left(\overline{P_H}\right)}{\left(N_{Li}+N_{Mi}+N_{Hi}\right)^2} \quad (31)$$

where

$\overline{P_i}$ = weighted monthly proportion of interviewed groups that were AT LERs for month i for site-type S,

N_{Li} =the total number of site-days in month i for stratum HF-L,

N_{Mi} =the total number of site-days in month i for stratum HF-M,

N_{Hi} =the total number of site-days in month i for stratum HF-H,

$\overline{P_L}$ =proportion of interviewed groups that were AT LERs for stratum HF-L,

$\overline{P_M}$ =proportion of interviewed groups that were AT LERs for stratum HF-M,

$\overline{P_H}$ =proportion of interviewed groups that were AT recreationists for stratum HF-H,

$\hat{V}\left(\overline{P_L}\right)$, $\hat{V}\left(\overline{P_M}\right)$and $\hat{V}\left(\overline{P_H}\right)$ are the estimated variances of $\overline{P_L}$, $\overline{P_M}$ and $\overline{P_H}$, respectively. The N_{Li}, N_{Mi} and N_{Hi} are referred to as strata weights and were obtained from the prework spreadsheets. he $\overline{P_L}$, $\overline{P_M}$, $\overline{P_H}$ and their variances were estimated from the Pilot Study survey data from only June 1 through August 14, 2007.

To convert the NPS people tally to group tally a similar weighted mean of all group size was computed as

$$\overline{G_i^a}=\frac{N_{Li}\overline{G_L^a}+N_{Mi}\overline{G_M^a}+N_{Hi}\overline{G_H^a}}{N_{Li}+N_{Mi}+N_{Hi}} \quad (32)$$

$$\hat{V}\left(\overline{G_i^a}\right)=\frac{N_{Li}^2\hat{V}\left(\overline{G_L^a}\right)+N_{Mi}^2\hat{V}\left(\overline{G_M^a}\right)+N_{Hi}^2\hat{V}\left(\overline{G_H^a}\right)}{\left(N_{Li}+N_{Mi}+N_{Hi}\right)^2} \quad (32)$$

where

$\overline{G_i^a}$ = average size of all groups for month i for site-type HF,

N_{Li} =the total number of site-days in month i for stratum HF-L,

N_{Mi} =the total number of site days in month i for stratum HF-M,

N_{Hi} =the total number of site days in month i for stratum HF-H,

$\overline{G_L^a}$ =average group size of all interviewed groups for stratum HF-L,

$\overline{G_M^a}$ =average group size of all interviewed groups AT for stratum HF-M,

$\overline{G_H^a}$ =average group size of all interviewed groups for stratum HF-H,

and $\hat{V}\left(\overline{G_L^a}\right)$, $\hat{V}\left(\overline{G_M^a}\right)$, and $\hat{V}\left(\overline{G_H^a}\right)$ are the estimated variances of $\overline{G_L^a}$, $\overline{G_M^a}$ and $\overline{G_H^a}$, respectively.

Also required was the monthly average group size for AT LERs defined as

$$\overline{G_i} = \frac{N_{Li}\overline{G_L} + N_{Mi}\overline{G_M} + N_{Hi}\overline{G_H}}{N_{Li} + N_{Mi} + N_{Hi}} \tag{33}$$

$$Var\left(\overline{G_i}\right) = \frac{N_{Li}^2\hat{V}\left(\overline{G_L}\right) + N_{Mi}^2\hat{V}\left(\overline{G_M}\right) + N_{Hi}^2\hat{V}\left(\overline{G_H}\right)}{\left(N_{Li} + N_{Mi} + N_{Hi}\right)^2} \tag{34}$$

where

$\overline{G_i}$ = average size of all groups for month i for site-type HF,

N_{Li} =the total number of site days in month i for stratum HF-L,

N_{Mi} =the total number of site days in month i for stratum HF-M,

N_{Hi} =the total number of site days in month i for stratum HF-H,

$\overline{G_L}$ =average group size of AT LER interviewed groups for stratum HF-L,

$\overline{G_M}$ =average group size of AT LER interviewed groups for stratum HF-M,

$\overline{G_H}$ =average group size of AT LER interviewed groups for stratum HF-H,

and $\hat{V}\left(\overline{G_L}\right)$, $\hat{V}\left(\overline{G_M}\right)$, and $\hat{V}\left(\overline{G_H}\right)$ are the estimated variances of $\overline{G_L}$, $\overline{G_M}$ and $\overline{G_H}$, respectively.

The visitation for the Pilot Survey utilizes these monthly weighted estimates and the monthly NPS proxy visitation estimate and is defined as

$$PROXY^S = \sum_{i=6}^{8} k\overline{P_i}\frac{PROXY_i^S}{\overline{G_i^a}}\overline{G_i} \qquad (35)$$

where k =1 if i =6 or 7 (June or July) and k=14/31 if i =8 (August) and

$PROXY^S$ = the proxy visitation estimate for the Pilot Survey for site-type HF

$PROXY_i^S$ =the official NPS visitation at Harpers Ferry, WV for month i, $i = 6,7,8$.

Note that in the above equation month 8 is multiplied by (14/31) to reflect that the Pilot Survey terminated on August 14. Also, the variance assumes that the proxy visitation $PROXY_i^S$ is known without error, that is, has zero variance.

The variance of the above estimator (35) is quite complicated because it is a product of a constant and three variables as well as a ratio of two correlated variables $\overline{G_i^a}$ and $\overline{G_i}$. To simplify maters, assume that $\overline{G_i^a}$ is a constant, which is reasonable because its variance is quite small. Then we have approximately

$$\hat{V}\left(PROXY^S\right) = \sum_{i=6}^{8} k^2\left(\frac{PROXY_i^S}{\overline{G_i^a}}\right)^2\left\{\overline{P}_i^2\hat{V}\left(\overline{G}_i\right) + \overline{G}_i^2\hat{V}\left(\overline{P}_i\right) - \hat{V}\left(\overline{P}_i\right)\hat{V}\left(\overline{G}_i\right)\right\} \qquad (36)$$

because $\hat{V}\left(\frac{\overline{PROXY_i^S}}{\overline{G_i^a}}\right) = 0$ by assumption which drops four terms out of the general variance equation (12), simplifying the variance to a product of only two variables and two constants.

Special day—The Pilot Survey identified Foundry Day at Boiling Springs, PA on June 2, 2007 as the only Special Day on the Pilot Study portion of the AT. Foundry Day was chosen as a Special Day because the celebration was known to draw thousands of visitors to Boiling Springs, potentially increasing use on the AT on that day to a level greatly exceeding the defined strata. In addition, Boiling Springs consisted of a complex of five sites (998, 999, 1000, 1001 and 1002) that intersected the town, resulting in unique sampling problems. Thus, due to these issues, it was felt that these site days did not fit the criteria of any of the thirteen strata and, thus, it was identified as a Special Day.

The methodology to estimate visitation at this Special Day followed the general concepts used for the other sites but with some modification. The Special Day estimator is the total number of AT recreation visitors in Boiling Springs, PA on June 2, 2007 and is defined as

$$\hat{SD} = \overline{P_{SD}}\, \hat{NG}_{SD}\, \overline{G}_{SD} \tag{37}$$

with estimated variance

$$\begin{aligned}\hat{V}\left(\hat{SD}\right) = {} & \overline{P_{SD}}^2\, \hat{NG}_{SD}^2\, \hat{V}\left(\overline{G_{SD}}\right) + \overline{P_{SD}}^2\, \overline{G_{SD}}^2 \hat{V}\left(\hat{NG}_{SD}\right) + \hat{NG}_{SD}^2\, \overline{G_{SD}}^2 \hat{V}\left(\overline{P_{SD}}\right) \\ & - \overline{P_{SD}}^2 \hat{V}\left(\hat{NG}_{SD}\right)\hat{V}\left(\overline{G_{SD}}\right) - \hat{NG}_{SD}^2\, \hat{V}\left(\overline{P_{SD}}\right)\hat{V}\left(\overline{G_{SD}}\right) \\ & - \overline{G_{SD}}^2 \hat{V}\left(\overline{P_{SD}}\right)\hat{V}\left(\hat{NG}_{SD}\right) + \hat{V}\left(\overline{P_{SD}}\right)\hat{V}\left(\hat{NG}_{SD}\right)\hat{V}\left(\overline{G_{SD}}\right)\end{aligned} \tag{38}$$

where

$\hat{SD}$ = estimator for the total number of AT recreating visitors in Boiling Springs, PA on June 2, 2007,

$\overline{P_{SD}}$ = the proportion of all groups interviewed that are AT recreating groups,

$\hat{NG}_{SD}$ = the number of groups of visitors (A.T and non-AT) in Boiling Springs, PA and

$\overline{G_{SD}}$ = the average group size for AT recreating groups.

Note that this approach deviates from the general methodology in that exiting people and vehicles are not used in the estimation process and $\overline{P_{SD}}$ and $\overline{G_{SD}}$ were not based on the last-exiting criterion. These deviations were necessary due to the complex nature of the trail intersections in Boiling Springs.

The major difficulty was to obtain an estimate of $\hat{NG}_{SD}$, the number of groups in Boiling Springs on Foundry Day. Initial investigation indicated that many visitors came to Boiling Springs via shuttle buses operating out of a local high school. Although these groups represented a portion of $\hat{NG}_{SD}$, there were other groups that came in private vehicles or simply walked to town. However, if somehow those who used the shuttle buses could be identified during the interviewing process, then typical mark-recapture methods used for estimating animal abundance (Seber 1982) could be used to estimate $\hat{NG}_{SD}$. This was accomplished by simply adding a question during the interview that asked if they used the shuttle buses.

The Lincoln-Petersen estimator is a simple mark-recapture estimator used for wildlife population size estimation. It consists of a two-sample process where animals are captured and marked in sample 1 and then a second sample is taken. The estimator is defined as

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 \tag{39}$$

with estimated variance

$$\hat{V}(\hat{N}) = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)} \tag{40}$$

where,

$\hat{N}$ = the Lincoln-Petersen estimate of population size,

n_1 = number of animals marked in first sample,

n_2 = number of animals marked in second sample and

m_2 = number of animals recaptured in the second sample that were marked in the first sample.

Applying the Lincoln-Peterson estimator to Boiling Springs, PA, let the first sample be the groups that took the shuttle bus and the second sample be the groups interviewed in town during the interviewing process. Although the groups in the first sample were not physically "marked", they could be detected in sample 2 by asking the additional question "Did you take the shuttle bus to town?" Thus, for this application, let

NG = number of visiting groups in Boiling Springs, PA,

n_1 = number of groups that took the shuttle bus,

n_2 = number of groups interviewed in Boiling Springs, PA and

m_2 = number of groups interviewed that took the shuttle bus.

Although the shuttle bus count was based on people, it may be converted to groups to give

$$n_1 = \frac{C^b}{\overline{G^b}} \tag{41}$$

where

C^b = the total number of people that took the shuttle bus and

$\overline{G^b}$ = the average group size for those groups that took the shuttle bus.

An estimator $\hat{NG}$ for the number of groups in Boiling Springs, PA is obtained by substituting these quantities into the general Lincoln-Petersen estimator (equation 39).

One component of the survey process at Boiling Springs, PA consisted of shuttle bus tallies. The shuttle bus operated from 9:00 am to 4:00 pm and transported people from the high school to the festivities in town. Survey personnel stationed at the school tallied 610 people being transported to town (table 4). However, the observer took a break between 10:59 am and 11:50 am (51 minutes) and, thus, the tally does not include this interval. To estimate the number of people on the buses during the break, the average number of people per minute was determined for approximately an hour before and an hour after the break. The hour before the break included the 10:02 to immediately prior 10:59 (57 minutes) bus tallies, totaling 191 people. The hour after the break included the 11:50 am to immediately prior 12:50 pm (60 minutes) bus tallies, totaling 94 people. The average people per minute is thus calculated as $(191+94)/(57+60) = 2.44$. The break was 51 minutes so the number of people during this interval is $51(2.44) = 124$. Note that although the break with no tallies was 51 minutes, the interval used was defined to include the 10:59 am to immediately prior to the 11:50 am bus tally which totaled 33 people. This is analogous to the methodology previously used to obtain the hourly bus tallies. Thus, subtracting

the number taken on the bus at the beginning of the break (10:59) from 124 gives the total number of unseen break bus people as 124-33=91. The total number of bus people is the sum of those seen on the buses plus those unseen people during the break, yielding $C^b = 610 + 91 = 701$.

The other survey component was the interviewing process. This was performed at two of the five sites (999 and 1000) in Boiling Springs from 8:00 am to 4:00 pm following the standard procedure with the addition of the extra question pertaining to the shuttle bus. A total of 26 groups were interviewed, with 12 using the AT for recreation, 10 not using the AT for recreation and 4 refusing to answer the interview. Thus, the proportion of groups that used the AT for recreation was $\overline{P_{SD}} = 12/22 = 0.5455$ with $\hat{V}\left(\overline{P_{SD}}\right) = 0.0113$ and n_2=22. During this period there were m_2=2 groups interviewed that took the shuttle bus with their average group size being $\overline{G^b}$=3.0 and, thus, using equation (41), $n_1 = 701/3.0 = 233.67$. For simplicity, ignore the variance and assume that n_1 is a constant. In addition, there were 11 groups interviewed that used the AT for recreation and for which group sizes were obtained, yielding an average group size of $\overline{G_{SD}}$ = 3.0909 with variance $\hat{V}\left(\overline{G_{SD}}\right)$=0.5901.

The above estimates could be used to obtain an estimate for $\hat{SD}$. Using the general Lincoln-Petersen estimator (equation 39)

$$\hat{NG} = \frac{(233.67+1)(22+1)}{(2+1)} - 1 = 1798$$

with estimated variance (equation 40)

$$\hat{V}\left(\hat{NG}\right) = \frac{(233.67+1)(22+1)(233.67-2)(22-2)}{(2+1)^2(2+2)} = 694{,}677$$

and substituting values into equation (37) yields the Special Day estimate

$$\hat{SD} = 0.5455(1798)(3.0909) = 3,032$$

with estimated variance (equation 38) $\hat{V}\left(\hat{SD}\right) = 3{,}114{,}724$.

Data Bases and Computer Programs

There are several types of data files created or collected in the Pilot Survey that have been archived as Microsoft Excel files (table 5). These consist of prework spreadsheet files and the sample calendar and sample backup file created from them. In addition, the observed data collected during the sample days are in the Day Summary and Individual Interview files. The auxiliary proxy data from the NPS are in two other files. Each of these will now be briefly discussed.

The initial step in the Pilot Survey was to create the sampling frame from which the sample was eventually selected. To accomplish this, all exiting sites in the Pilot region had to be identified. In addition, to perform an extrapolation to the entire AT, all sites had to be identified on the entire AT. This consisted of six prework spreadsheet files. The procedure for data entry follows that explained previously in the prework data set section. The variable names, type, length, description and permissible values are shown in table 6. The sample calendar and sample backup days were generated via a SAS program (SAS Institute Inc. 2004) that randomly selected the sample days according to specified criteria (table 5).

The observed data consist of nonproxy and proxy data. The Day Summary files contain basic information about the interviewer and the interview process for each sample day. Three levels of files are archived. The first level is A, which consists of data as entered from the field with no edit corrections. This file has limited applications, but serves as a benchmark for the original data. Level B consists of the data after minor, obvious errors have been corrected with what are known to be true corrections. These data may be useful to certain investigators wanting to analyze the data recording process itself or perform edit corrections based on their own decisions. Level C is a further modification where questionable data were altered based on certain logical considerations and knowledge about the survey process. These are the data that were considered the best for all estimates for the Pilot Survey. Information about the variables and their characteristics is listed in table 7. The Individual Interview files are the data recorded for each group interviewed for all the sample days. There are the A, B and C versions that serve the same purposes as outlined for the Day Summary files. Table 8 gives the characteristics for the variables. The proxy data are in two files, one for the site-type ATC (ATCPROXY_101508_SZ.xls) and the other for the site-type HF (HFPROXY_10092008.xls).

All mathematical and statistical computations were performed with SAS generated programs (SAS Institute Inc. 2004). A consistent, structured style was used in the programming process and numerous comments were incorporated to aid in explanation of the programming steps. The prework programs were developed to read in the prework spreadsheets, develop the sampling frame and then select the sample days according to the sample design. Two programs performed this function, one for the ATC and another for the rest of the Pilot region. The major programming effort was to develop the SAS estimation program which produced the many

estimated parameters and eventual visitation estimates based on the stratified random cluster sampling design. These SAS programs are listed in table 5.

Pilot Survey Results

Parameter estimates—The calibrating parameters consist of the $\overline{P_h}$, $\overline{G_h}$ and $\overline{G_h^a}$ which were estimated with the survey and model-assisted approaches. A comparison of these reveals that the model-assisted approach produces more stable and plausible estimates for the limited amount of data available from the Pilot Survey. The estimated $\overline{P_h}$ and standard errors for all strata for both approaches are shown in table 9. The survey approach yields for site-type TR an estimated $\overline{P_h} = 0.500$ for use-level L and $\overline{P_h} = 1.000$ for use-level M. Recalling that $\overline{P_h}$ is the proportion of exiting groups that are recreating and not returning to the AT on that day, it seems unreasonable that the true parameter values are so incongruent. This is probably due to the extremely low sample size of only eight and two interviewed groups, respectively. A similar problem occurs for stratum HF-L when compared to strata HF-M and HF-H. Alternately, the model-assisted approach produces more plausible parameter estimates in these situations because it incorporates the data from all site-types and use-levels to produce much smoother relationships as shown in fig. 6. For all site-types, use-level L is substantially less than M and H which are practically identical. In addition, the highest $\overline{P_h}$ is for site-type P followed by TR. This should be expected because these site-types are typically used only by AT hikers. The ATCH site-type is intermediate due to an approximate mixture of AT and non-AT visitors. Site-type MU (e.g., state parks through which the AT runs) is a little lower, reflecting higher percentages of non-AT visitors. The lowest $\overline{P_h}$ is for site-type HF due to the large proportion of visitors that are

recreating at Harpers Ferry National Historical Park and not using the AT. The standard errors are also more reasonable for the model-assisted approach. They are much smoother and are usually less than half that of the survey approach. The estimated $\overline{G_h}$ and $\overline{G_h^a}$ reveal similar trends, being smoother and more realistic for the model-assisted approach (tables 10 and 11) (fig. 7 and 8). Although the standard errors are usually lower for the model-assisted approach, they are not as substantially so as was the case for $\overline{P_h}$. It is also interesting to note that the model-assisted estimated for $\overline{G_h^a}$ is approximately 18 percent larger than that of $\overline{G_h}$. This supports the need for incorporating both $\overline{G_h^a}$ and $\overline{G_h}$ in the visitation estimators as was given in the Estimation Methodology section.

The results for the Pilot Survey parameter estimates reveal several justifications for preferring the model-assisted approach over the survey based approach. First, limited available resources resulted in low sampling intensity for certain strata which increased the risk of erratic estimates for the survey based approach. This was alleviated to a certain extent with the model-assisted approach because all the data are pooled, the relationship between site-type and use-level are modeled, and then the individual strata estimates are obtained from the model. Second, the model-assisted approach smoothes out the parameter estimates so that inconsistencies are eliminated to a large degree. For instance, if a parameter increases with increasing use-level for a given site-type, it will exhibit this pattern for the other site-types. The survey based approach does not have this property because the individual strata estimates are not linked via a common model. Third, the standard errors of the parameter estimates are substantially smaller with the model-assisted approach because all the data are pooled and used jointly in the estimation

process for all strata estimates of a parameter. Alternatively, the survey based approach estimates a stratum's parameter based only on the data observed in that stratum which results in a smaller sample size and, consequently, a larger standard error.

Despite the advantages of the model-assisted approach when the sampling intensity is low, the survey based approach is preferred when adequate sampling is affordable and has been achieved. In this situation, the sample based estimate for a given stratum is independent of the other strata and is capable of reflecting its individual characteristics and properties. It does not rely on a model which assumes no interaction between site-type and use-level which may be unrealistic in some surveys.

Guidelines for when to use the two estimation approaches are based on professional judgment and somewhat arbitrary rules of thumb. Generally, the goal in a survey is to estimate a parameter with a coefficient of variation (CV) of 10 percent or less. The CV is the ratio of the standard error divided by the parameter estimate converted to a percent. To achieve this for a proportion such as $\overline{P_h}$ under simple random sampling requires a sample size of 100 when the estimate of $\overline{P_h}$ is 0.5. The Pilot Survey was a cluster design so the calculation of required sample size is more complicated because sample size is defined by primary (clusters) and secondary (total number of observations within the clusters) sampling units. However, it is generally accepted that clustering is less efficient than simple random sampling, so it is safe to assume that the sample size of the secondary sampling units should be over 100. Referring to table 9, this criterion is not met for most of the strata. When parameter estimates are based on means such as $\overline{G_h}$ and $\overline{G_h^a}$ the calculation of required sample size is different but generally a sample size of 30 is considered

minimal for simple random sampling. Table 10 and 11 reveal that the number of secondary sampling units is usually less than 30 which is inadequate, even if one discards the cluster nature of the sampling design.

Another factor to consider when comparing the survey based and model-assisted approaches is subject matter expertise. Usually an analyst will have some knowledge about the parameters that are being estimated and can judge which approach produces more desirable estimates. For instance, the survey based approach yielded $\overline{P_h}$ =0.500 for the TR-L stratum and $\overline{P_h}$ =1.000 for the TR-M stratum (table 9). It seems highly unlikely that there would be such a difference in $\overline{P_h}$ between the L and M use-levels within the site-type TR. The model-assisted approach yields estimates of $\overline{P_h}$ =0.586 for the TR-L stratum and $\overline{P_h}$ =0.695 for the TR-H stratum (table 9) which appear to be more plausible. Thus, if this occurs for several of the strata, the model-assisted approach is the more desirable approach. However, caution must be used here to avoid selecting the approach that simply yields parameters estimates that result in any preconceived estimate of visitation that the analyst wishes to attain from the survey data.

The average daily clicker count for each strata was computed for the nonproxy site-types TR, P and MU as explained previously. They represent the average number of people based on a 12 hour day for all groups whether they represent LERs or not. The results follow what was anticipated with site-type TR being the lowest, site-type P being intermediate and site-type MU being the largest (table 12). The use-level relationship was also logical, with L being less than M which was less than H. This is not only reassuring here, but also provides further evidence that the prework and stratification process were valid.

The ATCH daily proxy tallies obtained from the ATC Headquarters ranged from 10 to 191 during the Pilot Survey period (table 13). Recall that these are the total number of people that exited the ATCH during a given day. The daily average for the two use-levels was 38.50 for M and 70.59 for H, which intuitively reflects the prework classification and stratification. The conversion from number of people to number of groups (LER and non-LER) resulted in 14.78 for M and 27.31 for H.

The 2007 proxy data for the site-type HF strata were obtained from the official NPS Harpers Ferry National Historical Park visitation estimates and reflects the sites 810, 811 and 813 (National Park Service 2008). The NPS monthly values ranged from 2,447 in February to 40,522 in July. In order to obtain estimates as outlined in the Estimation Methodology section, monthly weights had to be obtained for the three use-levels from which monthly weighted estimates of $\overline{P_i}$, $\overline{G_i}$ and $\overline{G_i^a}$ were computed (table 14). There was little variation for each of these estimates over the months. The $\overline{P_i}$ ranged from 0.074 to 0.096 with standard errors from 0.0305 to 0.0400. The $\overline{G_i}$ was even more consistent and ranged from 2.47 to 2.50 with standard errors from 0.387 to 0.508. The $\overline{G_i^a}$ were also quite consistent and ranged form 2.81 to 2.85 with standard errors ranging from 0.151 to 0.198.

Pilot survey visitation estimates—The visitation estimates were calculated based on the previous described methodology using the calibrating parameter estimates obtained by the survey and model-assisted approaches. The estimates based on each stratum along with standard errors, coefficients of variation and 95-percent confidence intervals are shown in table 15.

Converting total visits in each stratum to visits per day reveals the logical trends for the use-levels. Although there were many TR sites, average daily visits were slightly less than 3 according to either approach. The site-types P and MU were similar in visitation over the use-levels, with L being less than ten for both, while H ranged to near 60. The proxy ATCH average daily visitation was about 17 for M and 30 for H. The proxy HF site-type did not allow for individual use-level estimates because only monthly proxy data were available.

The pilot survey estimates reveal that the bulk of the visitation is from the P and MU site-types. Although there are many TR site days, the average visits per day are so low that their total visits are only about half or less than those of site-types MU or P. Nevertheless, because of the large number of site days, the TR-L stratum produces the second most visits of any individual stratum (table 15). The proxy site-types, ATCH and HF, have relatively large average daily visitation, but have few site days which also results in low total visitation.

A comparison of the total visit estimates on a strata basis for the two approaches reveals that they are quite similar for site-type P, MU, and ATCH for use-level H while for the other two use-levels they were substantially different with no pattern being exhibited. The estimates for site-type TR varied depending on use-level with the model-assisted approach being lower for use-level L while the survey approach was lower for use-level M. The ATCH site-type produced very nearly the same estimates for both approaches but the HF site-type was much different with the model-assisted approach yielding almost three times as much visitation as the survey approach. The precision of the estimates which depends on the standard error is best viewed through the coefficient of variation (CV) which gives the standard error as a percent of the

estimates. In nearly all strata the CV for the model-assisted approach is less than the survey approach. Despite this, both approaches have CVs that are usually much over 15 percent. This is reflected in many of the confidence intervals being very wide, with some actually having negative values. Thus, strata level estimates of visitation should be viewed with caution because of the large level of variability due to small sample size. It should be remembered that the objective of this survey was for an overall estimate in the Pilot Area and not strata level estimates. If strata level estimates are needed for future surveys, the sample sizes should be increased accordingly.

The comparison of the survey and model-assisted approaches indicate that very different estimates may often be obtained due to the differences in estimating the calibration parameters $\overline{P_h}$, $\overline{G_h}$ and $\overline{G_h^a}$ as described previously. In this case, the model-assisted approach appears more consistent with logical relationships for these calibration parameters than the survey approach. In addition, it produces smaller estimates of the standard errors of the calibration parameters and strata visitation estimates. Thus, the Pilot Survey visitation estimate will be based upon the model-assisted approach. However, in other surveys it is recommended that the survey approach be considered, especially when sufficient sample size is available to produce more stable estimates.

The Pilot Survey was principally designed to obtain overall visitation from June 1 through August 14, 2007 on the AT from Harpers Ferry, WV to ten trail miles north of Boiling Springs, PA at the Scott Farm. Thus, combining the model-assisted estimates over the nonproxy, the proxy ATCH, the proxy HF strata, and the Special Day yields the visitation estimates shown in

table 16. The total visitation for the Pilot Survey based on the model-assisted approach was 70,912 with 95 percent confidence intervals of 48,678 to 93,146. The CV was 16 percent which is considered quite good especially for the low level of sampling that was performed. The bulk of the visitation (83%) could be attributed to the nonproxy sites. The three HF sites at Harpers Ferry contributed a moderate share (9%), while the ATCH had a relatively small contribution (3%). However, it should be noted that these proxy sites (HF and ATCH) in Harpers Ferry account for about 12% of all AT visitation for the Pilot Survey. This is a large share considering the mileage of the AT running through Harpers Ferry relative to the mileage of the AT included in the Pilot Survey.

Part II – Trail-Wide Extrapolation

Overview

The estimates from the Pilot Survey were based on data collected over the spatial and temporal inference spaces defined by the objectives of the survey; however resource limitations precluded sampling over the entire AT for the whole year. Thus, for the Trail-Wide Extrapolation (TWE), some caution must be used when interpreting the various estimates and when using these estimates for management purposes. The first major assumption that was imposed is that the calibrating parameters $\overline{P_h}$, $\overline{G_h}$ and $\overline{G_h^a}$ for the TWE are the same as for the Pilot Survey. The stratification process of classifying sites days into site-types and use-levels should theoretically help to satisfy this assumption to a certain degree. For example, if a site was in stratum MU-L during the Pilot Survey, its group size $\overline{G_h}$ is probably quite similar to another site in stratum MU-L during the winter. However, it must be emphasized that the spring, fall and winter did not contribute any nonproxy data to the estimates and, thus, it is inevitable that some differences

could exist temporally and spatially. A second major assumption that may be more critical and difficult to accept is that the exit tallies $\overline{C_h}$ are the same for the Pilot Survey and the TWE. Although this issue was carefully considered and incorporated into the stratification process used for the whole AT, the Pilot Survey strata sample means could potentially be biased upwards with respect to the TWE because they are based only on summer data when there is more opportunity for larger groups with children to use the AT. A final major assumption for the TWE is that there were no festivals or events analogous to the Special Day at Boiling Springs where AT usage would have exceeded the L, M, H exit volume levels for the various site types. Omitting such days or events could lead to a negative bias in the extrapolation results. Despite these problems, the TWE estimation process described below is the optimal approach in lieu of the resources necessary to sample along the entire AT during the course of a complete year.

Sampling Design

The first step in the TWE was the prework which developed the sampling frame consisting of all site days along the entire AT from Mount Katahdin, Maine, to Springer Mountain, Georgia, from January 1, 2007 to December 31, 2007. This was performed as was described for the Pilot Survey and included the New England, MidAtlantic, Virginia and Southern Regions. Stratification was formed by the classification of all site days into the 15 potential strata formed by the combination of the five site-types and three use-levels. Unlike the Pilot Survey, the TWE did contain site days in strata ATCH-L and TR-H in which case special modifications were employed to obtain the intermediate quantities needed for visitation estimation. Due to limited resources and time, no other sites were added to the site-type HF strata except those previously discussed at Harpers Ferry, WV which were expanded to include the entire year. This was also

the case for site-type ATCH. Similarly, no Special Day sites other than Foundry Day at Boiling Springs, PA on June 2 were identified for the TWE. Undoubtedly there may be other site days along the AT with extraordinary characteristics like the site-types HF and ATCH, and Special Day at Boiling Springs. If such site days exist and are not explicitly accounted for, the TWE will exhibit a negative bias and be conservative. Future recommendations suggest that efforts be used to identify such sites along the entire AT.

The total TWE sampling frame consisted of 332,434 site days excluding the Special Day distributed by site-type and use-level as shown in table 2. The TR-L strata had the most site days, totaling 56 percent of the entire sampling frame followed by P-L with 24 percent. Although these two strata may represent low levels of daily visitation, they comprise 80 percent of all site days and, therefore, may have a large impact on the visitation estimate. The TWE designated all TR, P and MU site-types as nonproxy and the HF and ATCH site-types as proxy.

The number of sites identified as unique exit points for each of the regions was New England=239, Mid Atlantic (excluding Pilot) =319, Pilot=120, Virginia=146 and Southern=129, for a total of 953 with 849 open during the entire year. The percent of sites open all year for each of the regions was New England=67%, Mid Atlantic (excluding Pilot) =98%, Pilot=99%, Virginia=100% and Southern=86%, with the overall being 89%. The prework spreadsheet for the site-type ATCH was based on the proxy data obtained from the ATC Headquarters Office in Harpers Ferry, WV for the entire year as explained previously. The site-type HF was increased to include the NPS Harpers Ferry National Historical Park monthly visitation estimates for the

entire year. The TWE did not consist of any addition sampling but utilized the same sample selection and survey procedures used by the Pilot Survey.

Estimation Methodology

The TWE used the survey approach and the model-assisted approach for estimation of the calibrating parameters. The model-assisted approach was particularly appealing because it allowed for an estimation of the ATCH-L and TR-H strata parameters which were needed for the TWE visitation estimates despite no data for these strata being collected during the Pilot Survey. Relevant parameter estimates were derived using the relationships among all the site-types and use-levels developed with Pilot Survey data. However, the survey approach used a somewhat more arbitrary method to obtain these missing values by merely substituting the parameter estimate from the closest use-level in the site-type.

Total visitation for the TWE for the entire 2007 year is defined by equation (13) except that *VISITS* is the total number of recreation visits on the entire AT from January 1 to December 31, 2007.

The nonproxy component which consists of sites in the strata composed of the TR, P and MU site-types and all three use-levels L, M and H is obtained by equation (15) where the summation is extended from h=1 to 9 due to the inclusion of strata TR-H. The TWE uses the N_h based on the total AT prework data (table 2) but the $\overline{P_h}$, $\overline{C_h}$ and $\overline{G_h}$ are obtained from the Pilot Survey

based on equations (17), (19) and (22), respectively.

The site-type ATCH proxy data consisted of the 328 daily visitor tallies that the ATC Headquarters Office in Harpers Ferry, WV obtained throughout the entire year (only Pilot Survey data is shown in table 13). Note that 37 days were missed due to official closure of the ATCH or due to poor weather conditions (table 17). This was combined with the estimates $\overline{P_h}$ and $\overline{G_h}$ obtained from the six sample site days taken during the Pilot Survey at the ATCH. Let

N_h = total number of days that the ATCH has days in use-level h, $(h = L\ M\ H)$, during the entire year,

n_h = number of days the ATC Headquarters tallied visitation for stratum h during the entire year, and

$PROXY_{hi}^{ATCH}$ = the ATCH visitation tally on day i in use-level h,

then, the average daily proxy visitation tally in use-level h is the arithmetic mean as defined in equation (24). However, the estimated variance in equation (25) does not equal zero because n_h is less than N_h for use-level L and M, resulting in a non-vanishing finite population correction. The estimate for the ATCH for the TWE is obtained from equation (26) by extending the summation over all three use-levels and $\overline{P_h}$, $\overline{G_h}$ and $\overline{G_h^a}$ are calculated from the Pilot Survey data using equations (17), (22) and (27), respectively. As mentioned for the Pilot Survey, the variance equation (26) is quite complicated because it is a product of a constant and three variables as well as a ratio of a dependent variable. Previously, it was assumed that $\overline{G_h^a}$ was a constant, which is reasonable because its variance is quite small and it is highly correlated

with $\overline{G_h}$. However, due to the non-vanishing finite population correction $\hat{V}\left(\overline{PROXY_h^{ATCH}}\right) \neq 0$ for the TWE and a simplification can not be made. Therefore, equation (29) is extended over all three use levels and modified as

$$\hat{V}\left(PROXY^{ATCH}\right) =$$

$$\sum_{h=L}^{H}\left(\frac{N_h}{\overline{\overline{G_h^a}}}\right)^2\left\{\overline{P_h}^2\,\overline{PROXY_h^{ATCH}}^2\hat{V}\left(\overline{G_h}\right)+\overline{P_h}^2\,\overline{G_h}^2\hat{V}\left(\overline{PROXY_h^{ATCH}}\right)+\overline{PROXY_h^{ATCH}}^2\,\overline{G_h}^2\hat{V}\left(\overline{P_h}\right)\right\}$$

$$-\sum_{h=L}^{H}\left(\frac{N_h}{\overline{\overline{G_h^a}}}\right)^2\left\{\overline{P_h}^2\hat{V}\left(\overline{PROXY_h^{ATCH}}\right)\hat{V}\left(\overline{G_h}\right)+\overline{PROXY_h^{ATCH}}^2\hat{V}\left(\overline{P_h}\right)\hat{V}\left(\overline{G_h}\right)+\overline{G_h}^2\hat{V}\left(\overline{P_h}\right)\hat{V}\left(\overline{PROXY_h^{ATCH}}\right)\right\}$$

$$+\sum_{h-L}^{H}\left(\frac{N_h}{\overline{\overline{G_h^a}}}\right)^2\left\{\hat{V}\left(\overline{P_h}\right)\hat{V}\left(\overline{PROXY_h^{ATCH}}\right)\right\} \qquad (42)$$

The site-type HF sites consisted of the three sites located at Harpers Ferry (810, 811 and 813) and were estimated using the official monthly NPS Harpers Ferry National Historic Site visitation estimates as proxy data as was done for the Pilot Survey (table 14). This provided visitation estimates based on data for the total 365 days at Harpers Ferry which was considered superior to visitation estimates derived from the 20 site days that were planned to be sampled during the Pilot Study. However, there were several limitations to using this proxy data that had to be resolved. Recall that the NPS visitation included both AT and non-AT visits and was not stratified by use-level and was on a monthly basis. To resolve these problems required a monthly $\overline{P_i}$ derived from weighting the individual three use-level estimates obtained from the Pilot Study for site-type HF by the monthly strata weights obtained from the prework spreadsheet data as shown in equation (30). To convert the NPS people tally to group tally a similar weighted mean

of all group size was computed with equation (32). Also required was the monthly average group size for AT LERs defined by equation (33). The visitation for the TWE utilizes these monthly weighted estimates and the monthly NPS proxy visitation estimate and is defined by modifying equation (35) to extend over all 12 months with k =1 for all months.

The only Special Day identified for the TWE was Foundry Day at Boiling Springs, PA on June 2, 2007. Thus, the estimate from the Pilot was simply used in this instance.

Extrapolation Results

The visitation estimates were calculated based on the previously described methodology using the calibrating parameter estimates obtained by the Pilot Survey. Estimates were based on the survey-based and model-assisted approaches for comparison purposes. The estimates based on each stratum along with standard errors, coefficients of variation and 95 percent confidence intervals are shown in table 18. The TWE is based on data from the Pilot Survey and, thus, the relationships discussed previously are generally the same here.

The TWE estimates for both approaches are shown in table 16 for the nonproxy, the proxy ATCH, the proxy HF strata, the Special Day and the total. The total visitation for the entire AT using the model-assisted approach was 1,948,701 with a 95 percent confidence interval of 1,172,146 to 2,725,256. The CV was 20 percent which is considered quite good especially for the low level of sampling that was performed. The bulk of the visitation (99%) could be

attributed to the nonproxy sites because any additional sites like the site-types HF and ATCH and the Special Day were not identified outside of the Pilot Survey area.

The TWE using the survey-based approach yields similar findings to the model-assisted approach. The overall visitation estimate with the survey-based approach is 1,925,044 with a 95 percent confidence interval of 886, 457 to 2,963,630 and a CV of 28 percent.

Part III – Conclusions and Limitations

The main objective of this research was to develop a prototype survey design that could be used for estimating visitation on long, linear trails and apply this prototype to a major portion of the AT. The survey design framework produced a sampling frame based on exit sites that can be stratified by site-type and expected use-level or exit volume. It is believed that this structure could easily and efficiently be applied to other segments of the AT, as well as other long trails, with only minor modifications such as additional site-types and/or use-levels for both proxy and nonproxy sites, and special sites or days. The results of the Pilot Survey, based on the model-assisted approach, yielded a visitation estimate of 70,912, with a 95 percent confidence interval of 48,678 to 93,146, for the 75-day time period in 2007 from Harpers Ferry to ten trail miles north of Boiling Springs, PA at the Scott Farm.

Satisfying a second major research objective, these model-assisted results were extrapolated to produce an annual 2007 visitation estimate for entire Appalachian National Scenic Trail of 1,948,701, with a 95 percent confidence interval of 1,172,146 to 2,725,256. This estimate is

about 50 percent less than the previously reported annual AT visitation of 3 to 4 million (Appalachian Trail Conservancy 2009; National Park Service 2009b). Although the annual visitation estimate for the entire trail produced by our methodology is an extrapolation from the Pilot Survey, and is thus dependent on a number of assumptions (see the Overview subsection page 57-58) , it is scientifically defensible, and the methodology provides a structure for examining the various assumptions through sensitivity analyses.

The third objective of this project was to provide a preliminary estimate of the resources required for a survey of the entire Appalachian Trial for a full year as opposed to an extrapolation based on the Pilot Survey. Although it is possible to determine the number of sample site days required to achieve a specified level of precision given the total number of site days and level of variability for each stratum, we are only providing a rough guideline here. This is because the variances were at times poorly estimated, especially for the TR site-type where the use-levels were based on low sample size or for TR-H, not estimated at all.

First, consider that 25 sample site days are needed to provide an estimate of the strata means for each of the three use-levels in each of the site-types TR, P, and MU that are remotely located along the AT. Generally, a sample size of 25 is considered appropriate for a sample mean because this is where the t-distribution closely approaches the normal distribution and asymptotic properties of estimators begin to be achieved. Theoretically, a stratum like TR-L that has more total site days and possibly greater variability should have greater allocation than a stratum like MU-H. However, the visitation in TR_L is very low and it is felt more important to allocate more resources where the visitation is higher as in MU-H which will provide more interviews

that are not only useful for the visitation estimate but also for any of the other estimates that are addressed in the survey questionnaire. It is important to also keep in mind that at these sites where daily visitation may be low, especially site-type TR, some of the 25 site days may have no visitors and, hence, contribute no data for estimating some of the visitation parameters. Thus, allocating an equal sample size of 25 site days appears to be a good compromise between theoretical and practical considerations. The other two site-types, ATCH and S, are both located in Harpers Ferry, WV and consist of only three and one site, respectively. Thus, it was felt that 30 site days for each of these site-types, 10 per use-level, would be adequate. There was one Special Day in the Pilot Study but the total number along the entire AT was unknown. Thus, for lack of information, we assume there is one additional Special Day per each of the four AT Regions, yielding five Special Days in total. Based on this allocation, it is estimated that 290 sample site days distributed throughout the year would be adequate for a total annual AT visitation estimate.

The cost associated with sampling 290 site days and the analysis of the data consists of several components. Assuming an eight hour survey day at $15/hour and transportation costs of $20, gives a total cost of $140/day or $40,600 for all 290 site days. The data entry costs consist of manually entering data from the Daily Summary Forms and the Interview Forms for each site day at a rate of $15/hr. The cost of entering all the Daily Summary Forms is $435 assuming an entry rate of 10 per hour. Assuming 20 interviews per site day, the Interview Forms, which are a little longer and can be entered 8 per hour, would cost $10,875. Additional effort is needed for data editing, adjustments to the estimation computer program, analysis, and report writing, total $30,000. Fortunately, the questionnaire development and stratification of the entire AT has

already been accomplished and will entail no further costs. Travel, logistics, supplies, postage, and other miscellaneous items total an additional $5,000. Thus, an approximate estimate for performing an entire annual AT visitation survey would be $86,910. There is potential to reduce this by a substantial amount by not having to pay interviewers for their labor and data entry if sufficient volunteers could be obtained. With surveying spread over the entire year and trail, the concentration of interviewer work would also be spread out and this would probably be more conducive to obtaining volunteers.

The distinction between nonproxy and proxy sites proved quite useful for separating groups of estimators and resulted into more efficient estimators. Proxies are advantageous because they contain a “known” quantity that can be exploited to produce a less variable visitation estimate based in part on data that is collected outside the survey. In addition, this can lead to more optimal use of limited resources. In the present study, there were only two proxy site-types, HF and ATCH, but in other trail surveys there may be numerous proxies depending on the level of auxiliary information that is known about the trail. The HF proxy illustrated use of auxiliary data consisting of NPS monthly visitation estimates, while the ATCH proxy was based on very accurate daily visitation tallies obtained from the ATC. These illustrated two different methodologies to convert these proxies to appropriate visitation estimates. Undoubtedly, other sections of the AT, or other trails in general, could have different proxies such as fee tickets, parking lot counts, or mandatory registration that would require further adaptation of these methods for conversion.

There was only one Special Day identified in the survey and the application of mark-recapture methods commonly used with wildlife population was found useful in estimating this visitation. The value of isolating a Special Day instead of simply including the five site days in the MU-H strata resulted in 3,032 visits instead of 5(42.4)=212 visits obtained using the relevant nonproxy information. This difference emphasizes the importance of identifying all unique days in future surveys. Obviously, Special Days require knowledge of the site(s), and other innovative techniques besides mark-recapture methods may have to be employed. It is likely that some Special Days on trails may actually provide opportunity for complete censuses of LERs based on the specific administrative or coordination activities associated with the particular events.

One of the major problems in trail visitation estimation is that on-site sampling often results in sampled site days having low or no visitation, thus yielding no data for estimation of the important scale parameters $\overline{P_h}$, $\overline{G_h}$ and $\overline{G_h^a}$. Such low sampling intensity not only results in erratic estimates of these parameters with large variability as shown in this report, but is the reason why the visitation estimators are based on the product of their means instead of the mean of their individual daily product.

The model-assisted approach was used here in an attempt to mitigate the effect of small sample sizes on the design-based estimator. Results for the parameter estimates reveal several justifications for preferring the model-assisted approach over the design-based approach. First, limited resources can result in low sampling intensity for certain strata which increases the risk of erratic estimates for the design-based approach. This is alleviated to a certain extent with the model-assisted approach because the data are pooled, the relationship between site-type and use-

level is modeled, and then the individual strata estimates are obtained from the model. Second, the model-assisted approach smoothes the calibration parameter estimates so that inconsistencies are eliminated or mitigated. For instance, if a parameter increases with increasing use-level for a given site-type, it probably exhibits this pattern for the other site-types. The design-based approach does not have this property because the individual strata estimates are not linked via a common model. Third, the standard errors of the parameter estimates are substantially smaller with the model-assisted approach because all the data are pooled and used jointly in the estimation process. Alternatively, the design-based approach estimates a stratum's parameter based only on the data observed in that stratum, which results in a smaller sample size and, consequently, a larger standard error.

Despite the advantages of the model-assisted approach when the sampling intensity is low, the design-based approach is preferred when adequate sampling is affordable and has been achieved. In recreation use studies, this is rarely the case. With the design-based approach, the estimate for a given stratum is independent of the other strata and is capable of reflecting its individual characteristics and properties. It does not rely on a model which may or may not assume interaction between site-type and use-level.

Future research will hopefully allow sampling across the entire spatial and temporal range of the AT so that extrapolation is unnecessary to estimate overall annual visitation. Parameter and visitation estimates derived from the Pilot Survey, along with the trail-wide site day classification which was part of this research, will be fundamental to making a future trail-wide sampling and visitation estimate economically feasible.

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Table 1—The population of 120 sites in the pilot survey area from Harpers Ferry, WV, to ten trail miles north of Boiling Springs, PA at the Scott Farm.

Site Number	Site Name	Site-type
0	HF ATC HQ	ATCH
809	US 340	TR
810	(HF) VC shuttle parking	HF
811	(HF) Shenandoah Street (20)	HF
813	(HF) Lower Town	HF
814	C & O Canal Towpath E	TR
816	Keep Tryst (12)	P
817	Keep Tryst Road	TR
819	Weverton Road (30)	P
825	Gathland State Park S (larger 60 spot P)	MU
827	Gapland Rd	MU
828	Gathland State Park N (smaller 35 spot P)	MU
829	Lambs Knoll Road N	TR
832	Fox Gap (10)	P
833	Reno Monument Road	TR
834	Dahlgren Campground	P
835	South Mtn Inn (40) (US40A)	P
836	Dahlgren Chapel (15) ?	P
838	Monument Road	TR
839	Washington Monument Rd	MU
840	Wash. Monument Rd S (10 spot P)	MU
841	Wash. Monument Rd N (primary, 40 spot P)	MU
842	Wash. Monument Rd	MU
844	Boonsboro Mtn Road (3)	P
846	Boonsboro Mtn Road	TR
848	Trail	TR
849	US 40 Annapolis Rock (50)	P
853	Thurston Griggs side trail	TR
857	Blackrock Rd	TR
864	Wolfsville Road / MD 17 W (5)	P
865	Wolfsville Road / MD 17 E (10)	P
867	Trail	TR
869	MD 77	TR
872	Warner Gap Road (1)	P
874	MD 491 / Raven Rock Rd.	TR
875	High Rock (22)	P
878	Pen-Mar Road (40)	MU
881	Pen Mar High Rock Rd	TR
884	Buena Vista Road	TR
887	Old Rt. 16	TR
888	PA 16 (5) (resupply exit)	P
890	Mentzer Gap Road (3)	P

Site Number	Site Name	Site-type
891	Mentzer Gap Road	TR
893	Rattlesnake Run Road	TR
897	Rattlesnake Run Road (4)	P
899	trail to P (40)	TR
901	Rattlesnake Run Road (5)	P
903	Old Forge Road (3)	P
904	trail, unknown	TR
905	Snowy Mtn Tower Rd (3)	P
908	Swamp Road	TR
909	Raccon Run Trail	TR
910	PA 233 (3)	P
913	access road	TR
914	(CSP) US 30 / Trolley Trail	MU
915	(CSP) Ramble Trail W	MU
916	(CSP) Ramble Trail E	MU
917	(CSP) Bridge / A.T. / Park Trail	MU
919	W Parking (Chinquapin) neck	MU
920	(CSP) Three Valley Trail	MU
921	Locust Gap / Greenwd Furn S	MU
922	Locust Gap / Greenwd Furn N	MU
923	Hosack Run Trail	TR
924	Ridge Road	TR
925	Stillhouse / Ridge Rd Sandy Sod	TR
926	road, Methodist Hill	TR
927	Middle Ridge Road	TR
928	Hill Road	TR
929	Dughill Trail	TR
930	Ridge Road / Means Hollow	TR
931	Milesburn Rd	TR
932	Ridge Road	TR
933	Rocky Knob trail	TR
934	Fegley Rd	TR
935	trail, unknown	TR
937	Big Flat (12)	P
938	Dead Woman's Hollow (3)	P
942	Tumbling Run Game Pres. Rd	TR
946	Woodrow Road	TR
948	Michaux Road W	TR
949	Michaux Road E	P
950	Old Shippensburg Rd	P
951	PA 233 (3)	P
953	(PGF) Bendersville Road W	MU
954	Store / Hostel / Intersection S	MU
955	(PGF) Overnight / Dressing lot	MU
957	(PGF) Old Railroad Bed Rd (8)	MU

Site Number	Site Name	Site-type
958	Pole Steeple trail	TR
959	Old Forge Road	TR
961	trail, unknown	TR
962	Limekiln Road	TR
963	Tagg Run	TR
965	Pine Grove rd. / Tagg Run (2)	P
967	Hunters Run /PA 34 (10) Zeigler	P
970	Road / Trash Can Alley (10)	P
973	PA 94	TR
975	Old Sheet Iron Roof Road (6)	P
981	Old Town Road	TR
982	trail (to campground?)	TR
984	Whiskey Spring Park Mason-Dixon Tr (8)	P
987	Camp Tuckahoe trail	TR
988	White Rock Trail	TR
993	Gutshall, to P	TR
994	Ledigh Rd (10)	P
995	Ledigh Rd (5)	P
998	(BS) Mountain Road	MU
999	Butcher Hill Yellow Breeches Cr	MU
1000	BS, 1st St., Pa. 174	MU
1001	(BS) Butcher Hill Rd	MU
1002	(BS) PA 174 E	MU
1003	trail, unknown	TR
1004	PA 74	TR
1005	Lisburn Road (6)	P
1007	PA 641 / Trindle Road (4)	P
1009	Ridge Road	TR
1010	Old Stonehouse Road	TR
1011	Appalachian Drive	TR
1015	US 11	TR
1016	Bernheisel Road (6)	P
1019	Bernheisel Road (Scott Farm)	TR

Table 2—The total site days in each of the pilot study strata based on site-type and use-level, the original designed allocation of the sample of site days for AM and PM sampling (the actual achieved sample days in parentheses) and the total site days for the entire AT[1].

Site-type	Use-level	Pilot Survey Total Site Days	Allocated AM Sample Size (achieved)	Allocated PM Sample Size (achieved)	Allocated Sample Size Total (achieved)	AT Total Site Days[1]
TR	L	3,624	4 (4)	6 (8)	10 (12)	184,988
TR	M	651	4 (3)	6 (6)	10 (9)	8,112
TR	H	0	---	---	---	9,490
P	L	1,781	4 (4)	6 (7)	10 (11)	81,429
P	M	689	5 (6)	10 (7)	15 (13)	19,140
P	H	80	9 (8)	16 (12)	25 (20)	8,625
MU	L	1,161	4 (4)	6 (3)	10 (7)	13,279
MU	M	542	5 (5)	10 (10)	15 (15)	3,028
MU	H	167	9 (7)	16 (14)	25 (21)	2,883
HF[2]	L	156	1 (0)	3 (2)	4 (2)	791
HF[2]	M	23	2 (2)	3 (2)	5 (4)	156
HF[2]	H	46	4 (2)	7 (8)	11 (10)	148
ATCH[3]	L	0	---	---	---	120
ATCH[3]	M	14	---	---	2 (2)	157
ATCH[3]	H	61	---	---	4 (4)	88
Total[4,5]		8,995	51 (45)	89 (79)	146 (130)	332,434

[1] Does not include Foundry Day at Boiling Springs, PA, on June 2, 2007 which included 5 site days.
[2] HF are the sites 810, 811, and 813 at Harpers Ferry, WV.
[3] ATCH was sampled for approximately 7-8 hours each day so no AM and PM is indicated.
[4] Mather side trail was originally in the sampling frame, sample calendar and backup sample but was deleted from all of these.
[5] In the original prework site=881 was site type=MU and the sample calendar was developed from this. However, later the site was reclassified as site-type=TR which resulted in two more samples than planned in TR and two less in MU.

Table 3—The 2007 pilot survey sample calendar with 146 assigned sampling days along with two extra days. This does not include the special day at Boiling Springs, PA (June 2). If interviews are missing (.) then this scheduled sample day was missed.

Site	Sub(date) or Extra Day	Sitetype	Uselevel	Day	Month	Day	Time	Interviews
816		P	L	FRI	6	1	AM	5
836		P	M	FRI	6	1	PM	4
963		TR	L	FRI	6	1	PM	1
955		MU	H	SAT	6	2	AM	21
921		MU	L	SAT	6	2	AM	0
849	849(FRI 6/22)	P	H	SAT	6	2	AM	2
875	849(SAT 6/23)	P	H	SAT	6	2	AM	14
955		MU	H	SUN	6	3	PM	28
810		HF	H	SUN	6	3	PM	16
819		P	L	MON	6	4	AM	1
917		MU	L	THURS	6	7	AM	1
835		P	L	THURS	6	7	AM	0
999		MU	H	SAT	6	9	AM	3
875		P	H	SAT	6	9	AM	2
970		P	L	SAT	6	9	PM	0
819		P	H	SUN	6	10	AM	8
849		P	H	SUN	6	10	PM	15
0		ATCH	H	SUN	6	10	AM+PM	25
1000		MU	M	FRI	6	15	PM	7
849		P	H	FRI	6	15	PM	11
825		MU	H	SAT	6	16	AM	3
955		MU	H	SAT	6	16	PM	49
1000	1000(SAT 6/23)	MU	H	SAT	6	16	PM	12
849		P	H	SAT	6	16	PM	20
832		P	M	SAT	6	16	PM	5
937	849(WED 6/20)	P	M	SAT	6	16	PM	5
810		HF	H	SAT	6	16	PM	18
878		MU	M	SUN	6	17	AM	4
819		P	H	SUN	6	17	PM	6
849		P	H	SUN	6	17	AM	18
841		MU	M	MON	6	18	PM	0
893		TR	L	MON	6	18	PM	0
937		P	L	TUES	6	19	PM	1
819		P	L	WED	6	20	AM	1
825		MU	H	SAT	6	23	AM	2
999		MU	H	SUN	6	24	PM	6
836		P	M	SUN	6	24	PM	.
1000	Extra Day	MU	H	SUN	6	24	PM	1
0		ATCH	H	MON	6	25	AM+PM	16
920		MU	L	TUES	6	26	AM	13

Site	Sub(date) or Extra Day	Sitetype	Uselevel	Day	Month	Day	Time	Interviews
994		P	L	WED	6	27	PM	0
1011		TR	L	THURS	6	28	PM	0
1015		TR	M	THURS	6	28	AM	1
878		MU	M	FRI	6	29	AM	5
1000		MU	M	FRI	6	29	PM	7
811		HF	M	SAT	6	30	AM	15
917		MU	M	SUN	7	1	AM	20
819		P	H	SUN	7	1	AM	5
836		P	M	SUN	7	1	PM	4
810		HF	H	SUN	7	1	AM	34
813		HF	H	SUN	7	1	PM	40
903		P	L	MON	7	2	PM	0
811		HF	L	MON	7	2	PM	35
841		MU	H	TUES	7	3	AM	.
954		MU	M	WED	7	4	PM	10
849		P	H	WED	7	4	PM	12
875		P	H	WED	7	4	PM	0
832	888(SUN 8/5)	P	M	WED	7	4	PM	2
811		HF	M	WED	7	4	PM	34
923		TR	M	THURS	7	5	PM	0
999		MU	M	FRI	7	6	PM	6
849		P	H	FRI	7	6	PM	12
949		P	M	FRI	7	6	AM	0
921		MU	L	SAT	7	7	PM	1
999		MU	H	SUN	7	8	PM	6
890		P	M	SUN	7	8	AM	0
813		HF	H	SUN	7	8	PM	58
842		MU	L	MON	7	9	PM	.
841		MU	H	TUES	7	10	PM	.
901		P	L	WED	7	11	PM	0
881[1]		TR	L	THURS	7	12	PM	0
922		MU	L	THURS	7	12	PM	1
841		MU	H	SAT	7	14	PM	19
919	841(THURS 8/2)	MU	H	SAT	7	14	PM	4
917		MU	M	SAT	7	14	PM	6
819		P	H	SAT	7	14	PM	7
810	813(SUN 7/15)	HF	H	SAT	7	14	AM	46
813		HF	H	SAT	7	14	AM	35
811		HF	M	SAT	7	14	AM	20
833		TR	L	SAT	7	14	PM	1
875	875(SUN 8/12)	P	H	SUN	7	15	AM	0
865	888(WED 7/11)	P	M	SUN	7	15	PM	1
938		P	M	SUN	7	15	AM	1
811		HF	M	SUN	7	15	PM	41

Site	Sub(date) or Extra Day	Sitetype	Uselevel	Day	Month	Day	Time	Interviews
810		HF	L	MON	7	16	PM	21
924		TR	M	MON	7	16	AM	0
841		MU	H	TUES	7	17	AM	2
0		ATCH	H	TUES	7	17	AM+PM	7
841		MU	H	WED	7	18	PM	7
809		TR	L	WED	7	18	AM	1
881[1]		TR	L	THURS	7	19	PM	1
934		TR	L	FRI	7	20	PM	0
810		HF	H	SAT	7	21	PM	40
841		MU	H	SUN	7	22	PM	9
919		MU	H	SUN	7	22	PM	.
1002		MU	L	SUN	7	22	PM	25
849	849(SUN 7/29)[2]	P	H	SUN	7	22	PM	8
817		TR	L	SUN	7	22	AM	3
929	930(WED 8/8)	TR	L	SUN	7	22	AM	0
987		TR	M	MON	7	23	AM	0
841		MU	H	TUES	7	24	PM	12
999		MU	M	TUES	7	24	PM	3
920	920(SUN 7/29)[2]	MU	L	WED	7	25	AM	0
919		MU	M	WED	7	25	AM	7
849		P	M	WED	7	25	AM	0
810		HF	L	THURS	7	26	AM	.
933		TR	M	FRI	7	27	PM	0
1015		TR	M	FRI	7	27	PM	1
819		P	H	SAT	7	28	PM	.
875		P	H	SAT	7	28	AM	25
810		HF	H	SAT	7	28	PM	48
1015		TR	M	SAT	7	28	PM	0
955		MU	H	SUN	7	29	PM	.
875		P	H	SUN	7	29	PM	.
844		P	L	MON	7	30	PM	1
0		ATCH	H	MON	7	30	AM+PM	11
836		P	M	WED	8	1	PM	2
875		P	M	WED	8	1	PM	15
841		MU	H	FRI	8	3	PM	1
838	829(MON 7/16)	TR	L	FRI	8	3	AM	1
927		TR	L	FRI	8	3	PM	0
917		MU	M	SAT	8	4	PM	18
819		P	H	SAT	8	4	PM	.
875		P	H	SAT	8	4	PM	2
950		P	M	SAT	8	4	AM	1
811		HF	M	SAT	8	4	PM	.
925	933(TUES 8/7)	TR	M	SAT	8	4	PM	0
878		MU	M	SUN	8	5	PM	7

Site	Sub(date) or Extra Day	Sitetype	Uselevel	Day	Month	Day	Time	Interviews
819		P	H	SUN	8	5	AM	.
849		P	H	SUN	8	5	PM	8
875		P	H	SUN	8	5	PM	.
813		HF	H	SUN	8	5	AM	.
963		TR	M	MON	8	6	PM	0
938	Extra Day	P	L	MON	8	6	PM	0
0		ATCH	M	MON	8	6	AM+PM	3
841		MU	H	TUES	8	7	AM	.
811		HF	L	TUES	8	7	PM	.
0		ATCH	M	TUES	8	7	AM+PM	16
841		MU	H	WED	8	8	AM	6
955		MU	M	THURS	8	9	AM	1
841		MU	H	SAT	8	11	AM	5
919		MU	H	SAT	8	11	PM	2
899		TR	M	SAT	8	11	AM	.
849		P	H	SUN	8	12	PM	30
905		P	M	SUN	8	12	PM	.
813		HF	H	SUN	8	12	PM	50
919		MU	M	MON	8	13	PM	0
841		MU	H	TUES	8	14	PM	0

[1] Was originally site-type=MU but was later reclassified as site-type=TR.
[2] Not an official back up day but the site-type and use-level were appropriate.

Table 4—The Boiling Spring, PA, shuttle bus tallies on June 2, 2007.

Departure Time	Shuttle Bus people Count	Return Time
900	35	908
911	20	919
920	25	927
925	14	932
933	21	942
941	33	949
948	23	957
1002	48	1011
1010	32	1020
1019	25	1028
1029	42	1040
1038	10	1046
1049	34	1101
1059	33	---
---	91[1]	---
1150	35	1203
1202	24	1213
1212	20	1223
1220	8	1229
1228	3	1239
1235	4	1244
1250	11	1301
1303	25	1314
1310	20	1320
1321	4	1330
1325	8	1334
1336	8	1346
1340	5	1348
1351	10	1400
1408	7	1419
1414	5	1424
1425	1	1433
1432	2	1438
1440	1	1447
1448	0	1458
1453	2	1503
1504	5	1513
1514	1	1522
1523	0	1534
1528	6	1552
1601	0	1610

[1] A break was taken between 1059 and 1150 so no observations were recorded for the shuttle buses leaving between this interval. The value here is an approximation which is derived in the text.

Table 5—Data files and SAS programs used in the pilot survey and trail-wide extrapolation to the entire AT.

File Name	Description	Records[1]
PilotRegion_10152008_SZ.xls	Prework	409
ATCHRegion_10282008_SZ.xls	Prework	11
NewEnglandRegion_10142008_LLSZ.xls	Prework	631
MidAtlanticRegion_10202008_LLSZ.xls	Prework	770
Virginia_10142008_LLSZ.xls	Prework	467
SouthernRegion_10142008_LLSZ.xls	Prework	348
calendar.xls	Sample calendar	141
backup.xls	Sample backup sample days	184
ATCH_calendar.xls	ATC sample calendar	6
DSF_A_082008.xls	Original Day Summary data	133
DSF_B_082108_SZMB.xls	Slightly edited Day Summary data	130
DSF_C_100908_SZMB.xls	Final Day Summary data	130
IND_A_082008.xls	Original Individual Interview data	1432
IND_B_082108_SZMB.xls	Slightly edited Individual Interview data	1414
IND_C_090308_SZMB.xls	Final Individual Interview data	1233
ATCPROXY_101508_SZ.xls	ATC proxy visit data	365
HFPROXY_10092008_SZ.xls	Harpers Ferry proxy visit data	12
Prework_04252007.sas	SAS program to generate the sampling calendar	398
Prework_ATC.sas	SAS program to generate the sampling calendar for the ATC	46
estimation_11102008.sas	SAS program to produce the estimates	

[1] Does not include the header record if the file is an MS Excel (xls) data file.

Table 6—The prework data file showing variable names, type, length description, and permissible values.

Variable	Type[1]	Length	Description	Values[2]
SITENUM	N	8	Site number	0 to 1015
SITETYPE	C	3	Site-type	ATC, M[3], P, S[4], TR
USELEVEL	C	1	Use-level	L, M, H
BEGIN	N	8	Beginning date span	
END	N	8	Ending date span	
MONDAY	N	8	1=day has this uselevel blank=does not have this uselevel	1, blank
TUESDAY	N	8	1=day has this uselevel blank=does not have this uselevel	1, blank
WEDNESDAY	N	8	1=day has this uselevel blank=does not have this uselevel	1, blank
THURSDAY	N	8	1=day has this uselevel blank=does not have this uselevel	1, blank
FRIDAY	N	8	1=day has this uselevel blank=does not have this uselevel	1, blank
SATURDAY	N	8	1=day has this uselevel blank=does not have this uselevel	1, blank
SUNDAY	N	8	1=day has this uselevel blank=does not have this uselevel	1, blank
HOLIDAY	N	8	1=day has this uselevel blank=does not have this uselevel	1, blank

[1]C=Character variable and N=numeric variable.
[2] All character values are case sensitive.
[3] The site-type MU is coded as M in the data.
[4] The site-type HF is coded as S in the data.

Table 7—The day summary data file consists of 20 variables and 130 observations. The variables are currently in the file in this order based on the questionnaire, although a re-ordering may be more appropriate for clarity.

Variable	Type[1]	Length	Description	Values[2]
VEHICLESTART	N	8	Number of vehicles in parking lot at start of interview period	0 to 89
START	N	8	Time at start of interview period (military)	800 to 1630
INTERVIEWER	C	14	Person conducting interviews	Any name
CLICKPERSON	C	14	Person using clicker	Any name
DATE	N	8	Date of the survey	6/1/2007 to 8/14/2007
SITENUM	N	8	Site number	0 to 1015
SITENAME	C	27	Site name	Any name
WEATHER	C	19	Weather conditions	Any text
BREAK	N	8	Break time (minutes)	0 to 90
END	N	8	Time at end of interview period (military)	1300 to 2010
SUBSTITUTE	C	5	Is this a substitute day	NO, YES, EXTRA
ORIGINAL	C	17	Original sitenum and day if a substitute day	Any text
CLICKER	N	8	Total clicker count at end of interview period	0 to 230
TYPE	C	8	What was counted[3]	HIKERS, VEHICLES, NOTHING
VEHICLEEND	N	8	Number of vehicles in parking lot at end of interview period	0 to 150
SURVEYS	N	8	Total number of all surveys completed at end of interview period (??)	0 to 58
NOTES	C	502	Notes	Any text

[1]C=Character variable and N=numeric variable.

[2] All character values are case sensitive.

[3] Vehicles were counted at sites 825, 828, 840, 841, 878, 919, 955 and 999. Site 810, 811, and 813 are blank because there was no counting done. Hikers were counted at all other sites.

Table 8. The individual interview data file consists of 43 variables and 1233 observations (180 were RETURN which were deleted). The variables are currently in the file in this order based on the questionnaire, although a re-ordering may be more appropriate for clarity.

Variable	Type[1]	Length	Description	Values[2]
INTERVIEWER	C	15	Person conducting interviews	Any name
MONTH	N	8	Month for the survey	6,7,8
DAY	N	8	Day of the survey	1 to 30
YEAR	N	8	Year of the survey	2007
SITENUM	N	8	Site number	0 to 1015
SITETYPE	C	3	Site-type	ATC, M[3], P, S[4], TR
SITENAME	C	27	Site name	Any name
AGREE	N	8	Person agreed to take survey 0=no 1=yes	0, 1
MATHER	N	8	0=no (only at ATC) 1=yes	0, 1
ATUSE	N	8	Person used the AT today 0=no 1=yes	0, 1
REASON	C	9	Is AT the primary or secondary reason for the visit	PRIMARY, SECONDARY
PURPOSE	N	8	Purpose of visit 1=Recreation 2=non-recreation	1, 2
EXIT	C	5	Leaving AT for the day	LEAVE
TRANS	C	7	Transportation mode to AT	VEHICLE, BUS, BICYCLE, WALKING, OTHER
ARRMONTH	N	8	Month arrived at AT	2, 3, 4, 5, 6, 7, 8
ARRDAY	N	8	Day arrived at AT	1 to 30
ARRYEAR	N	8	Year arrived at AT	2007
ARRTIME	N	8	Time arrived at AT	500 to 2130
HIKE	N	8	Hiking distance on AT today 1=less than or equal 1 mile 2=over 1 but less than 5 miles 3=5 to less than 10 miles 4=10 or more miles	1, 2, 3, 4
VISITS	N	8	Visits to this AT site in last 12 months[5]	0 to 364
ATVISITS	N	8	Visits to any AT site in last 12 months[5]	0 to 365
ATVISITS_ADJ				
MALES	N	8	Males in group	0 to 22

Variable	Type[1]	Length	Description	Values[2]
FEMALES	N	8	Females in group	0 to 21
MALES16	N	8	Males less than 16 in group	0 to 12
FEMALES16	N	8	Females less than 16 in group	0 to 10
NIGHTS	N	8	Continuous nights on AT before today	0 to 100
SATISFIED	N	8	Satisfaction with AT 1=least satisfied 10=most satisfied	5, 6, 7, 8, 9, 10
CROWDED	N	8	Crowding on AT 1=not at all crowded 9=extremely crowded	1, 2, 3, 4, 5, 6, 7, 8, 9
MANAGE	C	82	Management Improvements	Any text
SPEND	N	8	Spent for this AT Visit (dollars)	0 to 8000
ZIPCODE	N	8	Zip code	1945 to 99999
AGE	N	8	Age class 16=16-20 21=21-30 31=31=40 41=41-50 51=51-60 61-61-70 71=71+	16, 21, 31, 41, 51, 61, 71
GENDER	C	1	Gender	F, M
HISPANIC	N	8	Hispanic or Latino	0, 1
NATIVE	N	8	Am. Indian/Alaska Native	0, 1
ASIAN	N	8	Asian	0, 0, 11
BLACK	N	8	Black	0,1
PACIFIC	N	8	Native Hawaiian/Pacific Islander	0, 1
WHITE	N	8	White	0, 1
REFUSED	N	8	Refused racial questions	0, 1
CLICKER	N	8	Clicker count including this interview	0 to 229
TIME	N	8	Time at interview end	802 to 1957

[1]C=Character variable and N=numeric variable.
[2] All character values are case sensitive.
[3] The site-type MU is coded as M in the data.
[4] The site-type HF is coded as S in the data.
[5]Does not include this visit.

Table 9—The estimated $\overline{P_h}$ for each site-type and use-level using the survey approach and the model-assisted approach.

Site-type	Use-level	Clusters	n	Survey $\overline{P_h}$	Survey SE	Model-Assisted $\overline{P_h}$	Model-Assisted SE
TR	L	6	8	0.500	0.256	0.586	0.124
TR	M	2	2	1.000	0.000	0.655	0.130
TR	H	0	0	1.000[1]	0.000[1]	0.695	0.130
P	L	5	9	0.650	0.138	0.696	0.053
P	M	10	40	0.696	0.221	0.765	0.036
P	H	18	205	0.819	0.115	0.805	0.025
MU	L	4	33	0.273	0.123	0.204	0.049
MU	M	13	92	0.273	0.104	0.273	0.031
MU	H	20	196	0.300	0.087	0.313	0.025
HF	L	2	56	0.018	0.022	0.061	0.049
HF	M	4	85	0.165	0.061	0.129	0.030
HF	H	10	341	0.164	0.037	0.170	0.020
ATCH	L	0	0	0.278[2]	0.130[2]	0.355	0.079
ATCH	M	2	18	0.278	0.130	0.424	0.067
ATCH	H	4	59	0.508	0.124	0.464	0.063

[1] The TR-H strata had no sample days so the survey approach $\overline{P_h}$ and SE are based on the TR-M strata.

[2] The ATCH-L strata had no sample days so the survey approach $\overline{P_h}$ and SE are based on the ATCH-M strata.

Table 10—The estimated $\overline{G_h}$ for each site-type and use-level using the survey approach and the model-assisted approach.

Site-type	Use-level	Clusters	n	Survey $\overline{G_h}$	Survey SE	Model-Assisted $\overline{G_h}$	Model-Assisted SE
TR	L	4	4	3.000	2.126	2.377	0.893
TR	M	2	2	1.000	0.000	2.246	0.960
TR	H	0	0	1.000[1]	0.000[1]	2.385	0.963
P	L	4	6	2.375	0.861	2.699	0.579
P	M	10	25	2.748	0.910	2.567	0.297
P	H	18	174	2.690	0.150	2.706	0.159
MU	L	3	9	2.600	0.421	2.602	0.570
MU	M	9	25	2.109	0.246	2.470	0.309
MU	H	12	59	2.771	0.370	2.609	0.250
HF	L	1	1	1.000	0.000[2]	2.506	0.623
HF	M	4	14	2.571	0.823	2.374	0.346
HF	H	10	63	2.478	0.332	2.514	0.260
ATCH	L	0	0	4.000[3]	0.800[3]	2.441	0.767
ATCH	M	2	5	4.000	0.800	2.309	0.568
ATCH	H	4	30	2.167	0.343	2.449	0.511

[1] The TR-H strata had no sample days so the survey approach $\overline{G_h}$ and SE are based on the TR-M strata.

[2] The HF-L strata had only one observation so the survey approach SE was set to 0.000 for computational simplicity.

[3]The ATCH-L strata had no sample days so the survey approach $\overline{G_h}$ and SE are based on the ATCH-M strata.

Table 11—The estimated $\overline{G_h^a}$ for each site-type and use-level using the survey approach and the model-assisted approach.

Site-type	Use-level	Clusters	n	Survey $\overline{G_h^a}$	Survey SE	Model-Assisted $\overline{G_h^a}$	Model-Assisted SE
TR	L	6	8	4.500	1.944	3.838	0.631
TR	M	2	2	1.000	0.000	3.649	0.662
TR	H	0	0	1.000[1]	0.000[1]	3.630	0.661
P	L	5	9	1.800	0.508	2.817	0.263
P	M	10	40	2.561	0.649	2.629	0.177
P	H	18	204	2.664	0.110	2.610	0.129
MU	L	5	41	2.896	0.452	2.943	0.236
MU	M	13	101	2.542	0.216	2.755	0.149
MU	H	19	189	2.871	0.249	2.736	0.128
HF	L	2	54	3.074	0.348	2.887	0.242
HF	M	4	110	2.973	0.266	2.698	0.143
HF	H	10	384	2.584	0.105	2.679	0.096
ATCH	L	0	0	2.474[2]	0.061[2]	2.792	0.398
ATCH	M	2	19	2.474	0.061	2.604	0.337
ATCH	H	4	59	2.627	0.545	2.585	0.321

[1] The TR-H strata had no sample days so the survey approach $\overline{G_h^a}$ and SE are based on the TR-M strata.

[2] The ATCH-L strata had no sample days so the survey approach $\overline{G_h^a}$ and SE are based on the ATCH-M strata.

Table 12—The average clicker count per sample day for each strata adjusted to a 12 hour recreation day. This represents the average number of groups of all types of people exiting.

Site-type	Use-level	Sample Days	Average	SE
TR	L	12	1.880	0.761
TR	M	9	0.506	0.375
TR	H	0	0.506[1]	0.375[1]
P	L	11	2.518	1.535
P	M	13	6.750	2.144
P	H	20	26.704	4.622
MU	L	7	13.689	9.603
MU	M	15	31.199	6.966
MU	H	21	51.939	17.436

[1] The TR-H strata had no sample days so the average and SE are based on the TR-M strata.

Table 13—Proxy counts for the ATCH from 9:00 am until 4:00 or 5:00 pm for the pilot survey from June 1 to August 14, 2007.

Date	Visitors	Hours	Date	Visitors	Hours
06/01/07	58	8	07/09/07	44	8
06/02/07	176	7	07/10/07	62	8
06/03/07	80	7	07/11/07	43	8
06/04/07	61	8	07/12/07	64	8
06/05/07	51	8	07/13/07	121	8
06/06/07	67	8	07/14/07	78	7
06/07/07	41	8	07/15/07	46	7
06/08/07	60	8	07/16/07	65	8
06/09/07	93	7	07/17/07	48	8
06/10/07	85	7	07/18/07	32	8
06/11/07	50	8	07/19/07	30	8
06/12/07	66	8	07/20/07	39	8
06/13/07	39	8	07/21/07	127	7
06/14/07	71	8	07/22/07	52	7
06/15/07	101	8	07/23/07	52	8
06/16/07	122	7	07/24/07	52	8
06/17/07	77	7	07/25/07	20	8
06/18/07	68	8	07/26/07	47	8
06/19/07	75	8	07/27/07	31	8
06/20/07	37	8	07/28/07	80	7
06/21/07	65	8	07/29/07	43	7
06/22/07	76	8	07/30/07	65	8
06/23/07	191	7	07/31/07	25	8
06/24/07	63	7	08/01/07	47	8
06/25/07	61	8	08/02/07	35	8
06/26/07	58	8	08/03/07	31	8
06/27/07	72	8	08/04/07	55	7
06/28/07	78	8	08/05/07	48	7
06/29/07	78	8	08/06/07	10	8
06/30/07	109	7	08/07/07	45	8
07/01/07	148	7	08/08/07	33	8
07/02/07	102	8	08/09/07	24	8
07/03/07	62	8	08/10/07	26	8
07/04/07	88	7	08/11/07	84	7
07/05/07	54	8	08/12/07	42	7
07/06/07	80	8	08/13/07	38	8
07/07/07	109	7	08/14/07	21	8
07/08/07	68	7			

Table 14—The monthly proxy counts, strata weights, weighted $\overline{P_i}$, $\overline{G_i}$ and $\overline{G_i^a}$ estimates and standard errors for the Harpers Ferry proxy data under the model-assisted approach.

Month	Monthly Proxy Count	Wt L	Wt M	Wt H	$\overline{P_i}$	$\overline{P_i}$ SE	$\overline{G_i}$	$\overline{G_i}$ SE	$\overline{G_i^a}$	$\overline{G_i^a}$ SE
Jan	3,389	74	17	2	0.076	0.0393	2.48	0.500	2.85	0.194
Feb	2,447	68	16	0	0.074	0.0400	2.48	0.508	2.85	0.198
Mar	10,803	75	18	0	0.074	0.0399	2.48	0.507	2.85	0.197
Apr	20,390	63	9	18	0.089	0.0346	2.49	0.440	2.83	0.171
May	32,597	66	9	18	0.088	0.0350	2.49	0.446	2.83	0.173
June	32,243	63	9	18	0.089	0.0346	2.49	0.440	2.83	0.171
July	40,522	63	10	20	0.091	0.0336	2.49	0.427	2.82	0.166
Aug	26,520	69	8	16	0.085	0.0365	2.50	0.465	2.83	0.181
Sept	28,160	57	11	22	0.096	0.0316	2.49	0.402	2.81	0.156
Oct	32,243	66	9	18	0.088	0.0350	2.49	0.446	2.83	0.173
Nov	15,383	71	17	2	0.076	0.0390	2.48	0.496	2.85	0.193
Dec	5,211	56	23	14	0.094	0.0305	2.47	0.387	2.81	0.151
Total	249,908									

Table 15—Pilot survey visitation (site-type HF represents the summation over all use-levels and all three sites because monthly proxy data was used). The first line of each pair represents the survey estimates and the second the model-assisted estimates.

Site-type	Use-level	Total Site Days	Visits per Day	Total Visits	SE	CV	Lower 95 CI	Upper 95 CI
TR	L	3624	2.8	10,217	8,505	83	-6,453	26,887
TR	L	3,624	2.6	9,493	5,318	56	-931	19,918
TR	M	651	0.5	329	244	74	-150	808
TR	M	651	0.7	484	390	80	-279	1,248
TR	H	0	---	---	---	---	---	---
TR	H	0	---	---	---	---	---	---
P	L	1,781	3.9	6,923	4,792	69	-2,469	16,315
P	L	1,781	4.7	8,422	5,355	64	-2,073	18,917
P	M	689	12.9	8,893	4,710	53	-339	18,125
P	M	689	13.2	9,127	3,094	34	3,063	15,191
P	H	80	58.8	4,704	1,072	23	2,603	6,806
P	H	80	58.2	4,653	861	19	2,965	6,341
MU	L	1,161	9.7	11,269	8,778	78	-5,936	28,475
MU	L	1,161	7.3	8,430	6,217	74	-3,756	20,616
MU	M	542	18.0	9,732	4,331	45	1,243	18,221
MU	M	542	21.0	11,382	3,148	28	5,213	17,551
MU	H	167	43.1	7,205	3,241	45	852	13,557
MU	H	167	42.4	7,078	2,518	36	2,144	12,012
ATCH	L	0	---	---	---	---	---	---
ATCH	L	0	---	---	---	---	---	---
ATCH	M	14	17.3	242	121	50	5	479
ATCH	M	14	14.5	203	59	29	87	318
ATCH	H	61	29.6	1,806	521	29	785	2,827
ATCH	H	61	31.0	1,892	469	25	973	2,811
HF	L,M,H	75	34.8	2,614	499	19	1,636	3,591
HF	L,M,H	75	89.5	6,716	1,740	26	3,306	10,125

Site-type	Use-level	Total Site Days	Visits per Day	Total Visits	SE	CV	Lower 95 CI	Upper 95 CI
Special	---	---	---	3,032	1,765	58	-427	6,491
Total				66,967	15,122	23	37,328	96,605
Total				70,912	11,344	16	48,678	93,146

Table 16—The final visitation estimates for the pilot survey and the trail-wide extrapolation for the entire AT.

Estimate	Total Visits	SE	CV	Lower 95 CI	Upper 95 CI
Survey-Based Approach					
Pilot Nonproxy	59,273	15,001	25	29,872	88,674
Pilot ATCH	2,048	535	26	1,000	3,096
Pilot HF	2,614	499	19	1,636	3,591
Pilot Special Day	3,032	1,765	58	-427	6,491
Pilot Total	66,967	15,122	23	37,328	96,605
Model-Assisted Approach					
Pilot Nonproxy	59,070	11,060	19	37,392	80,747
Pilot ATCH	2,095	472	23	1,169	3,021
Pilot HF	6,716	1,740	26	3,306	10,125
Pilot Special Day	3,032	1,765	58	-427	6,491
Pilot Total	70,912	11,344	16	48,678	93,146
Survey-Based Approach					
AT Nonproxy	1,908,847	529,885	28	870,272	2,947,423
AT ATCH	5,720	1,468	26	2,844	8,597
AT HF	7,444	788	11	5,899	8,989
AT Special Day	3,032	1,765	58	-427	6,491
AT Total	1,925044	529,891	28	886,457	2,963,630
Model-Assisted Approach					
AT Nonproxy	1,921,047	396,187	21	1,144,522	2,697,573
AT ATCH	5,239	916	17	3,444	7,034
AT HF	19,383	2,785	14	13,923	24,842
AT Special Day	3,032	1,765	58	-427	6,491
AT Total	1,948,701	396,201	20	1,172,146	2,725,256

Table 17—The days when the ATC Headquarters Office in Harpers Ferry, WV, were officially closed or closed due to weather. Some closed days had visitor counts because they were opened partially or closed early due to bad weather conditions.

Month	Officially Closed	Due to Weather
January	1, 6, 7, 13, 14, 15, 20, 21, 27, 28	18
February	3, 4, 10, 11, 17, 18, 19, 24, 25	8, 13, 14
March	3, 4, 10, 11, 17, 18, 24, 25	
November	22	
December	22, 23, 25, 29, 30	

Table 18—Trail-wide extrapolation visitation (site-type=HF represents the summation over all use-levels and all three sites because monthly proxy data was used). The first line of each pair represents the survey estimates and the second the model-assisted estimates.

Site-type	Use-level	Total Site Days	Visits per Day	Total Visits	SE	CV	Lower 95	Upper 95
TR	L	184,988	2.8	521,552	434,145	83	-329,372	1,372,476
TR	L	184,988	2.6	484,593	271,482	56	-47,512	1,016,699
TR	M	8,112	0.5	4,103	3,044	74	-1,864	10,069
TR	M	8,112	0.7	6,033	4,854	80	-3,480	15,547
TR	H	9,490	0.5	4,800	3,561	74	-2,181	11,780
TR	H	9,490	0.8	7,957	6,351	80	-4,490	20,404
P	L	81,429	3.9	316,510	219,085	69	-112,896	745,916
P	L	81,429	4.7	385,048	244,821	64	-94,801	864,898
P	M	19,140	12.9	247,039	130,846	53	-9,420	503,497
P	M	19,140	13.2	253,553	85,944	34	85,102	422,004
P	H	8,625	58.8	507,200	115,581	23	280,661	733,739
P	H	8,625	58.2	501,664	92,837	19	319,704	683,625
MU	L	13,279	9.7	128,893	100,403	78	-67,898	325,684
MU	L	13,279	7.3	96,417	71,110	74	-42,959	235,792
MU	M	3,028	18.0	54,372	24,197	45	6,946	101,797
MU	M	3,028	21.0	63,589	17,585	28	29,123	98,055
MU	H	2,883	43.1	124,380	55,953	45	14,712	234,049
MU	H	2,883	42.4	122,193	43,462	36	37,008	207,377
ATCH	L	120	5.6	676	338	50	15	1,338
ATCH	L	120	3.9	467	177	38	120	815
ATCH	M	157	15.5	2,431	1,213	50	53	4,808
ATCH	M	157	13.0	2,033	589	29	837	3,188
ATCH	H	88	29.7	2,613	754	29	1,136	4,091
ATCH	H	88	31.1	2,739	678	25	1,409	4,046
HF	L,M,H	365	20.4	7,444	788	11	5,899	8,989
HF	L,M,H	365	53.1	19,383	2,785	14	13,923	24,842

Site-type	Use-level	Total Site Days	Visits per Day	Total Visits	SE	CV	Lower 95	Upper 95
Special	---	---	---	3,032	1,765	58	-427	6,491
Total				1,925,044	529,891	28	886,457	2,963,630
Total				1,948,701	396,201	20	1,172,146	2,725,256

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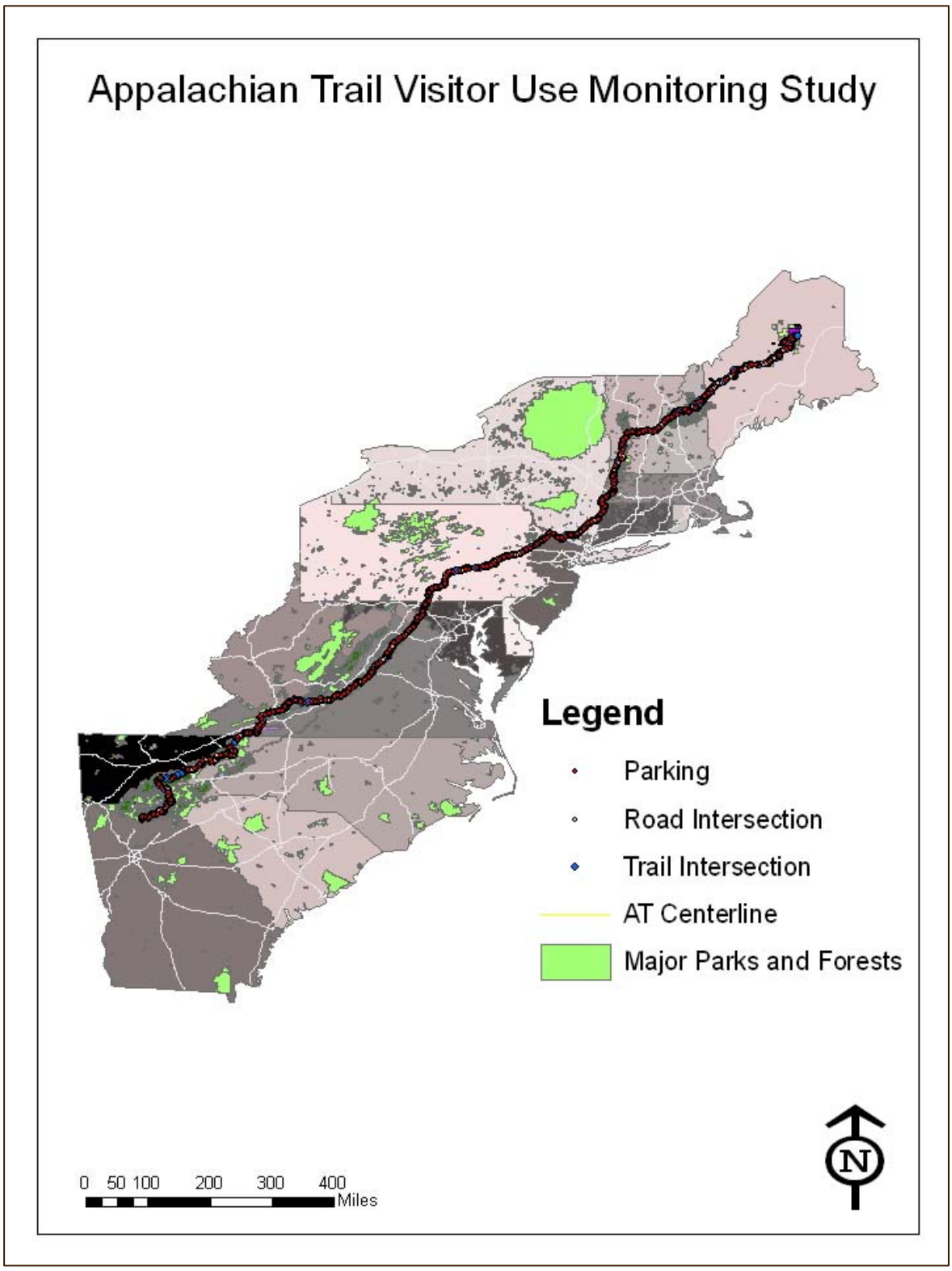

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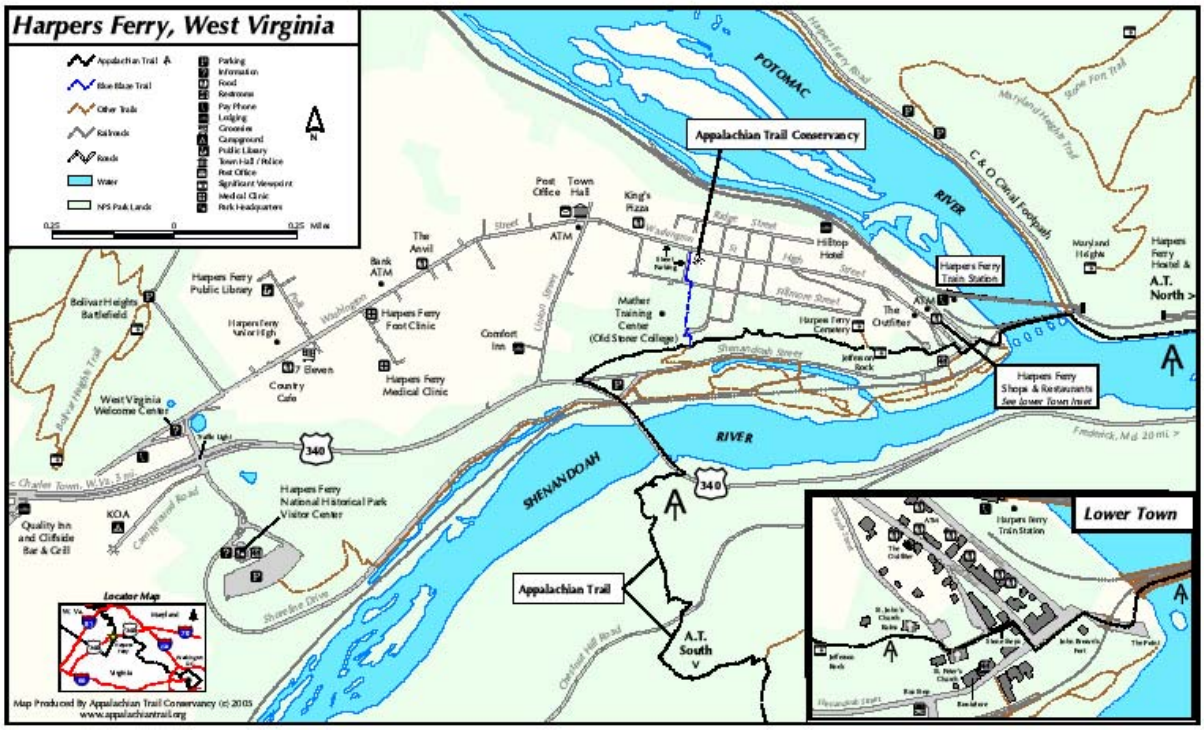


Figure 4—The survey questionnaire used to record information for each interviewed person on a sample day. An additional question (1.4) was only asked when sampling at the ATC.

NVUM / Appalachian Trail Visitor Use Study **ATC**

OMB #0596-0110 Interviewer:_____

Date: ___ /___ / 2007 Site # ATC Type M / HF Site Name:

_____

Q1: **Hi. We are conducting a study for the National Park Service. Would you be willing to take a few minutes to participate in an interview?**

_____ Yes (person agreed to be interviewed – read Introduction)

_____ No (did not agree to be interviewed – politely stop interview and visually obtain answers to Q 10, 11, 19)

If in group: "**I need to select just one of you to complete this interview. To make sure the survey is random, which of you had the most recent birthday and is 16 or older?"**

(Direct all questions to this person) **"Please take a moment and review the following information."** Important- Allow interviewee to read OMB Information.

Q1.4: **Did you arrive here via the Blue Blaze / Mather Side Trail?** _____ Yes

(ATC) _____ No

If at Special Site / M *(Q1.5 only):*

Q1.5: **Did you use the Appalachian Trail today?**
_____ Yes (continue to Q2)
_____ No "We are only surveying people who are using the Appalachian Trail. Thank you for your time." (visually obtain Q 10, 11, 19)

Q2. **Is the AT your primary or secondary reason for visiting this area today?**

Primary _____ Secondary _____

Q3: **Is the purpose of your visit to the Appalachian Trail for recreation?**

_____ Yes, recreation type answer (ex. hiking, bird-watching, etc. continue to Q4)

_____ No, non-recreation (maintainer, volunteer, etc.) "We are only surveying people who are here for recreation. Thank you for your time." (visually obtain Q 10, 11, 19)

Q4: **Are you leaving the AT for the day, OR will you return and continue on today?**

_____ Leaving the AT for the day (continue to Q4)

_____ Will return and continue on today "We are only surveying people who are exiting for the last time today. Thank you for your time." (visually obtain Q 10, 11, 19)

Q5: **How did you arrive at the AT today?**

Read: Personal vehicle ____ Bus____ Bicycle ____ Walking ____

Other ____

Q6: **When did you arrive at the AT for this visit?**

_____ Today: **What Time?** _____ (24 hr.)

_____ Earlier: **When?** Date: _____/ _____/ 2007 & Time: _____ (24 hr.)

Q7: **About how far did you hike on the AT today?**

1 mile or less _____ More than 1 but less than 5 miles _____

5 or more but less than 10 miles _____ 10 or more miles _____

Q8: **Not including this visit, about how many times have you visited this particular AT site for recreation in the past 12 months? _____**

Q9: **Not including this visit, about how many times have you visited anywhere along the AT for recreation in the past 12 months? _____**

Q10: **How many males and females are in your group today?**

Male: _____ Female: _____

Q11**: How many of those are less than 16 years old?** Male: _____ Female:_____

Q12: **How many continuous nights before today did you stay on the AT? _____**

Q13: **On a scale of 1-10, with 10 being the most satisfied, how satisfied were you with this visit to the Appalachian Trail**? **_____**

Q14: **On a scale of 1 – 9, with 9 being extremely crowded and 1 being Not at All Crowded, how crowded did you feel on the Appalachian Trail on this trip?** (circle one #)

Not at all Crowded | Slightly Crowded | Moderately Crowded | Extremely Crowded

1 2 3 4 5 6 7 8 9

Q15: **If you could ask Managers to improve <u>one thing</u> about the way people experience the Appalachian Trail, what would you ask them to do?**

_____

Q16: **Consider the food, fuel, lodging, equipment and other expenditures necessary for this visit. About how much did your group spend in total for this visit to the A.T?** (Note: "If your trip involves visits to multiple places, estimate only the share of spending for this visit to the AT") $ _____

Q17: **What is your home Zip Code?** _____ (*99999 if foreign*)

Q18: **What is your age group?** 16-20 21-30 31-40 41-50 51-60 61-70 71+

Q19: **What is your Gender?** M / F

Q20: **Are you Hispanic or Latino(a)?**

No_____ Yes_____ (Refused) _____

Q21: **With which racial group(s) do you most closely identify? Please choose one or more.**

_____ American Indian / Alaska Native

_____ Asian

_____ Black / African American

_____ Native Hawaiian or other Pacific Islander

_____ White

Clicker count (including this interview):_____

_____ (Refused) End Interview Time: _____(24 hr.)

Figure 5—The day summary form used to record information for each sample day.

Appalachian Trail Visitor Use Study

Interview Day Summary Form

Complete this form at the end of the interview period.

Interview Team

Person conducting Interviews: _____

Person using clicker: _____

Date and Times

Date: ____/____/_2007_ Weather Conditions: _____

Site # _____ Site name: _____

Time at start of interview period: _____ (military)

Time at end of interview period: _____ (military)

Scheduled shift: 8 – 2 (Am) or 2 – 8 (Pm)

Break time (in minutes): _____

Is this a Substitute Sample Day? Yes No

If so, what was the Original site number / day? #_____ ___/___/___07

Daily Clicker Counts

Total clicker / tally count at the **end** of interview period: _____

Did you count:

_____ Exiting Hikers **or** _____Vehicles

(Vehicles are counted at sites 825, 828, 840, 841, 878, 919, 955 and 999)

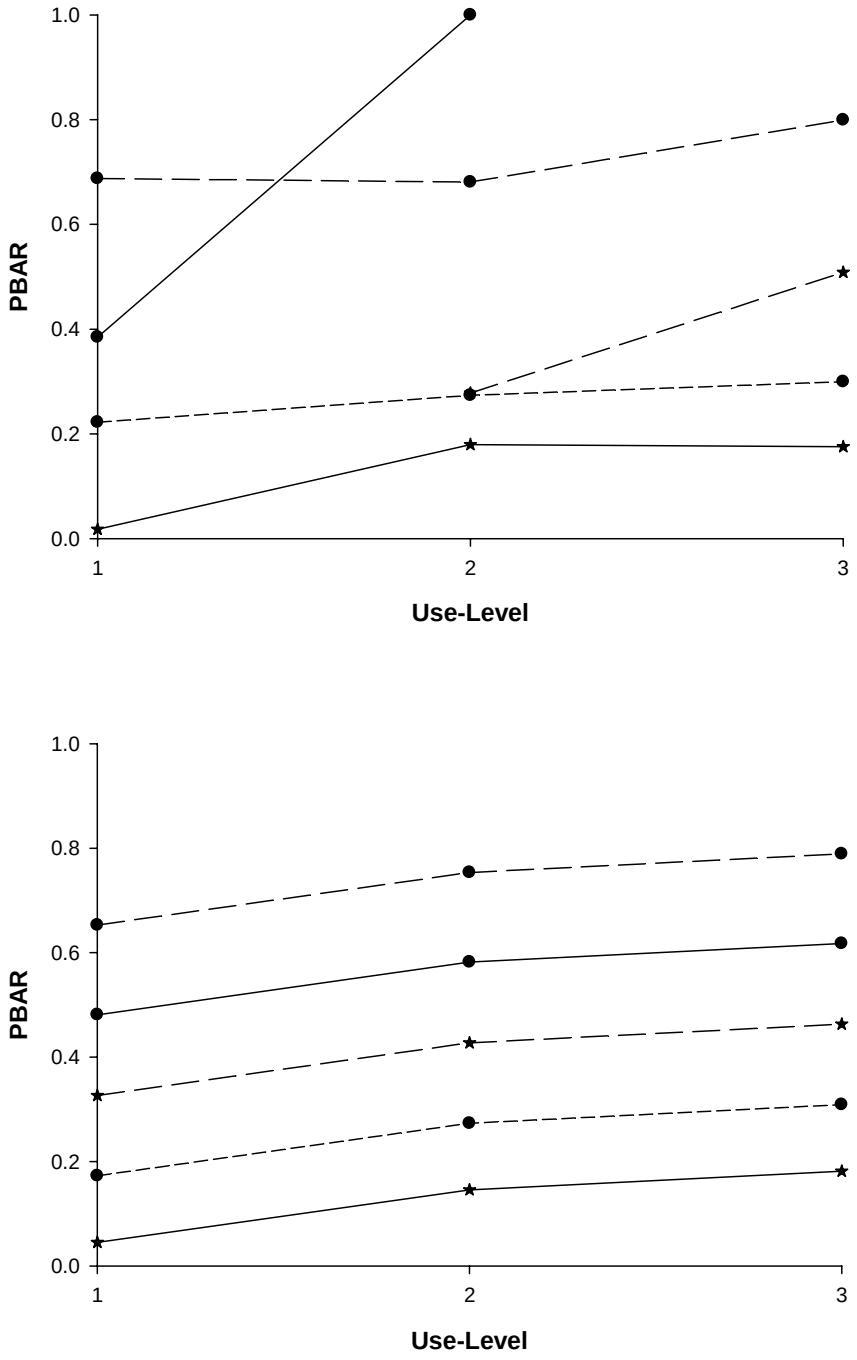
Index Estimate

Number of vehicles in parking lot: Shift Start_____ Shift End _____

Completed Interviews

Total Number of Surveys Completed at **end** of interview period: _____

Figure 6—The relationship of estimated $\overline{P_h}$ and use-level for the five site-types using the survey approach (top graph) and the model-assisted approach (bottom graph). The circles represent the nonproxy strata where TR=solid, P=long dash and MU=short dash. The stars represent the proxy strata where HF=solid and ATCH=long dash.



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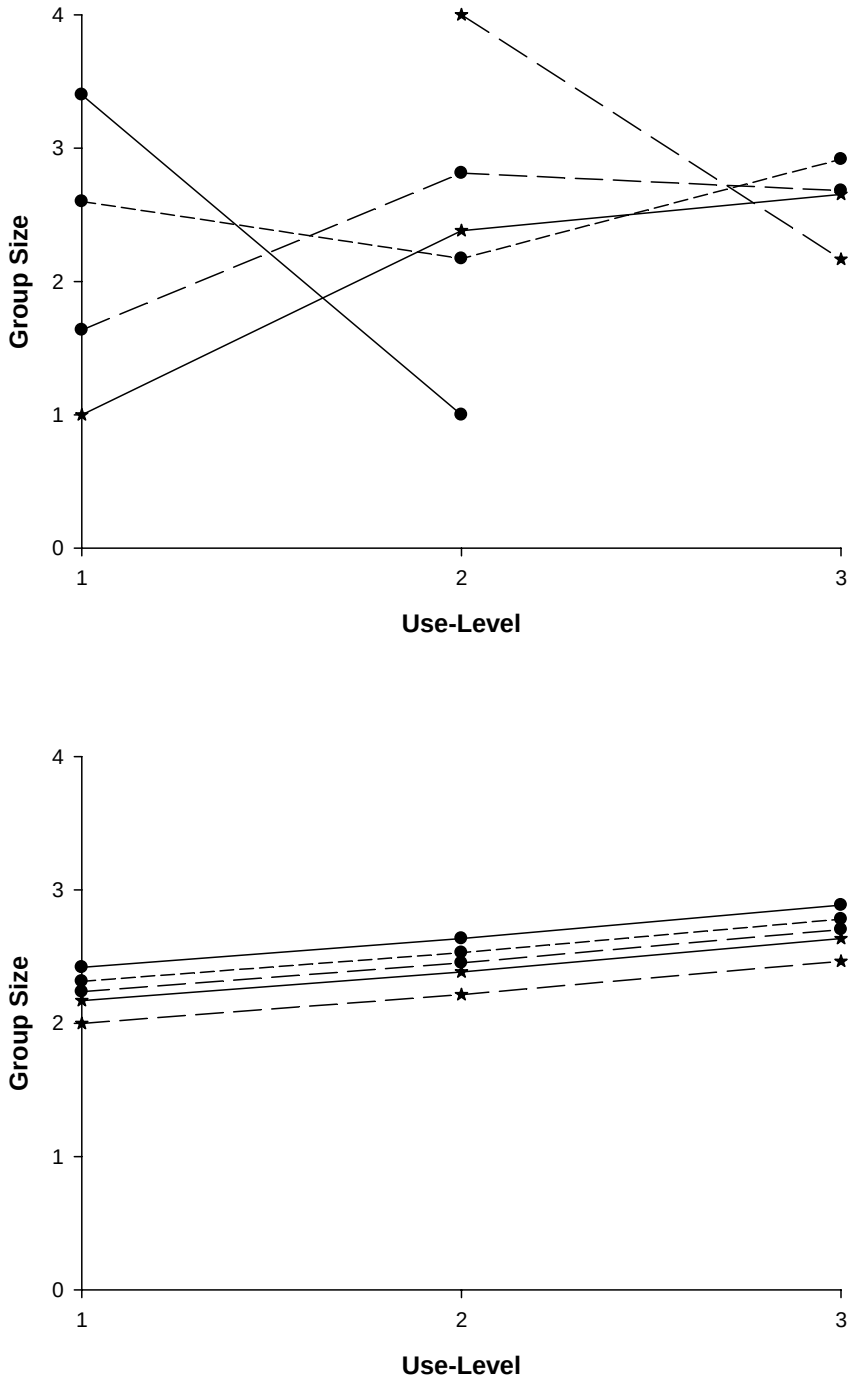

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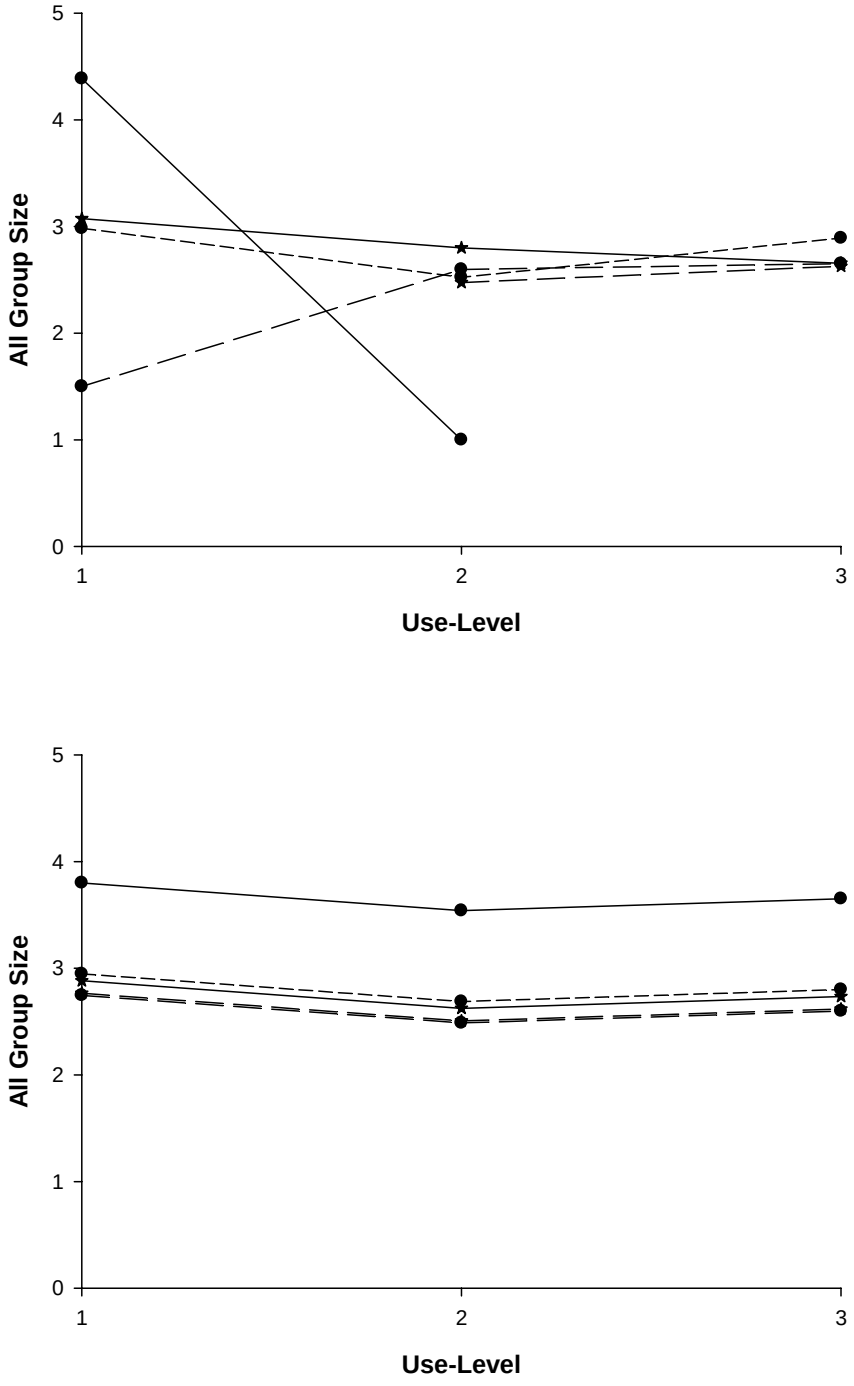

Appendix 1—The pilot survey prework spreadsheet consists of all the sites classified into site-types and use-levels for the entire 2007calendar year. The pilot survey actually used only those site days from June 1 through August 14, 2007. The site names that correspond to the site numbers can be found in table 1.

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
0	ATCH	L	101	330	1	1	1	1	1	1	1	
0	ATCH	M	331	430	1	1	1	1	1			
0	ATCH	H	331	430						1	1	
0	ATCH	M	501	531	1	1	1	1	1			
0	ATCH	H	501	531						1	1	1
0	ATCH	H	601	731	1	1	1	1	1	1	1	1
0	ATCH	M	801	930	1	1	1	1	1	1	1	1
0	ATCH	M	1001	1031	1	1	1	1	1			1
0	ATCH	H	1001	1031						1	1	
0	ATCH	M	1101	1130	1	1	1	1	1	1	1	1
0	ATCH	L	1201	1231	1	1	1	1	1	1	1	1
809	TR	L	101	1231	1	1	1	1	1	1	1	1
810	HF	L	102	1224	1	1	1	1	1			
810	HF	M	102	331						1	1	
810	HF	M	1101	1224						1	1	
810	HF	H	101	101	1							
810	HF	H	401	1031						1	1	
810	HF	H	1225	1231	1	1	1	1	1	1	1	
810	HF	H	101	1231								1
811	HF	L	102	331	1	1	1	1	1	1	1	
811	HF	L	401	1031	1	1	1	1	1			
811	HF	L	1101	1224	1	1	1	1	1	1	1	
811	HF	M	101	101	1							
811	HF	M	401	1031						1	1	
811	HF	M	1225	1231	1	1	1	1	1	1	1	
811	HF	M	101	1231								1
812	HF	L	101	1231	1	1	1	1	1	1	1	1
813	HF	L	102	1224	1	1	1	1	1			
813	HF	M	102	331						1	1	
813	HF	M	1101	1224						1	1	
813	HF	H	101	101	1							
813	HF	H	401	1031						1	1	
813	HF	H	1225	1231	1	1	1	1	1	1	1	
813	HF	H	101	1231								1
814	TR	L	101	1231	1	1	1	1	1	1	1	1
816	P	L	102	331	1	1	1	1	1	1	1	
816	P	L	401	1031	1	1	1	1	1			
816	P	L	1101	1224	1	1	1	1	1	1	1	
816	P	M	101	101	1							
816	P	M	401	1031						1	1	
816	P	M	1225	1231	1	1	1	1	1	1	1	
816	P	M	101	1231								1
817	TR	L	101	1231	1	1	1	1	1	1	1	1

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
819	P	L	102	1224	1	1	1	1	1			
819	P	M	102	331						1	1	
819	P	M	1101	1224						1	1	
819	P	H	101	101	1							
819	P	H	401	1031						1	1	
819	P	H	1225	1231	1	1	1	1	1	1	1	
819	P	H	101	1231								1
828	MU	L	102	331	1	1	1	1	1	1	1	
828	MU	L	401	1031	1	1	1	1	1			
828	MU	L	1101	1224	1	1	1	1	1	1	1	
828	MU	M	101	101	1							
828	MU	M	401	1031						1	1	
828	MU	M	1225	1231	1	1	1	1	1	1	1	
828	MU	M	101	1231								1
827	MU	L	101	1231	1	1	1	1	1	1	1	1
825	MU	L	102	1224	1	1	1	1	1			
825	MU	M	102	331						1	1	
825	MU	M	1101	1224						1	1	
825	MU	H	101	101	1							
825	MU	H	401	1031						1	1	
825	MU	H	1225	1231	1	1	1	1	1	1	1	
825	MU	H	101	1231								1
829	TR	L	101	1231	1	1	1	1	1	1	1	1
832	P	L	101	331	1	1	1	1	1	1	1	
832	P	L	401	1031	1	1	1	1	1			
832	P	L	1101	1231	1	1	1	1	1	1	1	
832	P	M	401	1031						1	1	
832	P	M	101	1231								1
833	TR	L	101	1231	1	1	1	1	1	1	1	1
834	P	L	401	430	1	1	1	1	1	1	1	
834	P	L	801	1130	1	1	1	1	1	1	1	1
834	P	M	501	731	1	1	1	1	1	1	1	1
835	P	L	101	331	1	1	1	1	1	1	1	
835	P	L	401	1031	1	1	1	1	1			
835	P	L	1101	1231	1	1	1	1	1	1	1	
835	P	M	401	1031						1	1	
835	P	M	101	1231								1
836	P	L	101	228	1	1	1	1	1	1	1	
836	P	L	301	531	1	1	1	1	1			
836	P	L	1001	1031	1	1	1	1	1			
836	P	L	1101	1231	1	1	1	1	1	1	1	
836	P	L	704	704								1
836	P	L	903	903								1
836	P	L	1122	1122								1
836	P	M	301	531						1	1	
836	P	M	1001	1031						1	1	
836	P	M	601	930	1	1	1	1	1	1	1	
836	P	M	528	528								1

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
836	P	M	1008	1008								1
838	TR	L	101	1231	1	1	1	1	1	1	1	1
839	MU	L	101	1231	1	1	1	1	1	1	1	1
841	MU	L	101	228	1	1	1	1	1	1	1	1
841	MU	L	301	430	1	1	1	1	1			
841	MU	L	901	1031	1	1	1	1	1			
841	MU	L	1101	1231	1	1	1	1	1	1	1	1
841	MU	M	301	430						1	1	
841	MU	M	501	630	1	1	1	1	1			
841	MU	H	501	630						1	1	
841	MU	H	701	831	1	1	1	1	1	1	1	
841	MU	H	901	1031						1	1	
841	MU	H	528	1008								1
840	MU	L	101	1231	1	1	1	1	1	1	1	1
842	MU	L	101	1231	1	1	1	1	1	1	1	1
844	P	L	101	1231	1	1	1	1	1	1	1	1
846	TR	L	101	1231	1	1	1	1	1	1	1	1
848	TR	L	101	1231	1	1	1	1	1	1	1	1
849	P	L	101	228	1	1	1	1	1	1	1	
849	P	L	301	531	1	1	1	1	1			
849	P	L	1101	1231	1	1	1	1	1			
849	P	M	301	531						1	1	
849	P	M	601	1031	1	1	1	1				
849	P	M	1101	1231						1	1	
849	P	H	601	1031					1	1	1	
849	P	H	101	1231								1
853	TR	L	101	331	1	1	1	1	1	1	1	
853	TR	L	1101	1231	1	1	1	1	1	1	1	
853	TR	L	401	1031	1	1	1	1	1			
853	TR	M	401	1031						1	1	
853	TR	M	401	1031								1
853	TR	M	1122	1122				1	1			1
857	TR	L	101	1231	1	1	1	1	1	1	1	1
864	P	L	101	331	1	1	1	1	1	1	1	
864	P	L	401	1031	1	1	1	1	1			
864	P	L	1101	1231	1	1	1	1	1	1	1	
864	P	M	401	1031						1	1	
864	P	M	101	1231								1
865	P	L	101	331	1	1	1	1	1	1	1	
865	P	L	401	1031	1	1	1	1	1			
865	P	L	1101	1231	1	1	1	1	1	1	1	
865	P	M	401	1031						1	1	
865	P	M	101	1231								1
867	TR	L	101	331	1	1	1	1	1	1	1	
867	TR	L	401	1031	1	1	1	1	1			
867	TR	L	1101	1231	1	1	1	1	1	1	1	
867	TR	M	401	1031						1	1	
867	TR	M	101	1231								1

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
869	TR	L	101	1231	1	1	1	1	1	1	1	1
872	P	L	101	1231	1	1	1	1	1	1	1	1
874	TR	L	101	1231	1	1	1	1	1	1	1	1
875	P	L	101	331	1	1	1	1	1	1	1	
875	P	L	1101	1131	1	1	1	1	1			
875	P	L	1201	1231	1	1	1	1	1	1	1	
875	P	M	401	531	1	1	1	1	1	1	1	
875	P	M	601	1031	1	1	1	1	1			
875	P	M	1101	1130						1	1	
875	P	H	601	1031						1	1	
875	P	H	101	1231								1
878	MU	L	101	331	1	1	1	1	1	1	1	
878	MU	L	1101	1231	1	1	1	1	1	1	1	1
878	MU	L	401	430	1	1	1	1	1			
878	MU	L	1001	1031	1	1	1	1	1			
878	MU	M	401	430						1	1	
878	MU	M	1001	1031						1	1	1
878	MU	M	501	930	1	1	1	1	1	1	1	1
881	TR	L	101	1231	1	1	1	1	1	1	1	1
884	TR	L	101	1231	1	1	1	1	1	1	1	1
887	TR	L	101	1231	1	1	1	1	1	1	1	1
888	P	L	101	630	1	1	1	1	1			
888	P	L	901	1231	1	1	1	1	1			
888	P	M	101	630						1	1	
888	P	M	701	831	1	1	1	1	1	1	1	
888	P	M	901	1231						1	1	
888	P	M	101	1231								1
890	P	L	101	331	1	1	1	1	1	1	1	
890	P	L	401	1031	1	1	1	1	1			
890	P	L	1101	1231	1	1	1	1	1	1	1	
890	P	M	401	1031						1	1	
890	P	M	101	1231								1
891	TR	L	101	1231	1	1	1	1	1	1	1	1
893	TR	L	101	1231	1	1	1	1	1	1	1	1
897	P	L	101	331	1	1	1	1	1	1	1	
897	P	L	401	1031	1	1	1	1	1			
897	P	L	1101	1231	1	1	1	1	1	1	1	
897	P	M	401	1031						1	1	
897	P	M	101	1231								1
899	TR	L	101	430	1	1	1	1	1	1	1	
899	TR	L	501	630	1	1	1	1	1			
899	TR	L	901	1031	1	1	1	1	1			
899	TR	L	1101	1231	1	1	1	1	1	1	1	
899	TR	M	501	630						1	1	
899	TR	M	701	831	1	1	1	1	1	1	1	
899	TR	M	901	1031						1	1	
899	TR	M	101	1231								1
901	P	L	101	331	1	1	1	1	1	1	1	

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
901	P	L	401	1031	1	1	1	1	1			
901	P	L	1101	1231	1	1	1	1	1	1	1	
901	P	M	401	1031						1	1	
901	P	M	101	1231								1
903	P	L	101	331	1	1	1	1	1	1	1	
903	P	L	401	1031	1	1	1	1	1			
903	P	L	1101	1231	1	1	1	1	1	1	1	
903	P	M	401	1031						1	1	
903	P	M	101	1231								1
904	TR	L	101	1231	1	1	1	1	1	1	1	1
905	P	L	101	331	1	1	1	1	1	1	1	
905	P	L	401	1031	1	1	1	1	1			
905	P	L	1101	1231	1	1	1	1	1	1	1	
905	P	M	401	1031						1	1	
905	P	M	101	1231								1
908	TR	L	101	1231	1	1	1	1	1	1	1	1
909	TR	L	101	430	1	1	1	1	1	1	1	
909	TR	L	501	630	1	1	1	1	1			
909	TR	L	901	1031	1	1	1	1	1			
909	TR	L	1101	1231	1	1	1	1	1	1	1	
909	TR	M	501	630						1	1	
909	TR	M	701	831	1	1	1	1	1	1	1	
909	TR	M	901	1031						1	1	
909	TR	M	101	1231								1
910	P	L	101	331	1	1	1	1	1	1	1	
910	P	L	401	1031	1	1	1	1	1			
910	P	L	1101	1231	1	1	1	1	1	1	1	
910	P	M	401	1031						1	1	
910	P	M	101	1231								1
913	TR	L	101	1231	1	1	1	1	1	1	1	1
914	MU	L	101	1231	1	1	1	1	1	1	1	1
915	MU	L	101	1231	1	1	1	1	1	1	1	1
916	MU	L	102	331	1	1	1	1	1	1	1	
916	MU	L	401	1031	1	1	1	1	1			
916	MU	L	1101	1224	1	1	1	1	1	1	1	
916	MU	M	101	101	1							
916	MU	M	401	1031						1	1	
916	MU	M	1225	1231	1	1	1	1	1	1	1	
916	MU	M	101	1231								1
917	MU	L	102	331	1	1	1	1	1	1	1	
917	MU	L	401	1031	1	1	1	1	1			
917	MU	L	1101	1224	1	1	1	1	1	1	1	
917	MU	M	101	101	1							
917	MU	M	401	1031						1	1	
917	MU	M	1225	1231	1	1	1	1	1	1	1	
917	MU	M	101	1231								1
919	MU	L	101	331	1	1	1	1	1	1	1	
919	MU	L	401	531	1	1	1	1	1			

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
919	MU	L	901	1130	1	1	1	1	1			
919	MU	L	1201	1231	1	1	1	1	1	1	1	
919	MU	M	401	531						1	1	
919	MU	M	601	831	1	1	1	1	1			
919	MU	M	1001	1130						1	1	
919	MU	H	601	930						1	1	
919	MU	H	101	1231								1
920	MU	L	101	1231	1	1	1	1	1	1	1	1
921	MU	L	101	1231	1	1	1	1	1	1	1	1
922	MU	L	101	1231	1	1	1	1	1	1	1	1
923	TR	L	101	430	1	1	1	1	1	1	1	
923	TR	L	501	630	1	1	1	1	1			
923	TR	L	901	1031	1	1	1	1	1			
923	TR	L	1101	1231	1	1	1	1	1	1	1	
923	TR	M	501	630						1	1	
923	TR	M	701	831	1	1	1	1	1	1	1	
923	TR	M	901	1031						1	1	
923	TR	M	101	1231								1
924	TR	L	101	430	1	1	1	1	1	1	1	
924	TR	L	501	630	1	1	1	1	1			
924	TR	L	901	1031	1	1	1	1	1			
924	TR	L	1101	1231	1	1	1	1	1	1	1	
924	TR	M	501	630						1	1	
924	TR	M	701	831	1	1	1	1	1	1	1	
924	TR	M	901	1031						1	1	
924	TR	M	101	1231								1
925	TR	L	101	430	1	1	1	1	1	1	1	
925	TR	L	501	630	1	1	1	1	1			
925	TR	L	901	1031	1	1	1	1	1			
925	TR	L	1101	1231	1	1	1	1	1	1	1	
925	TR	M	501	630						1	1	
925	TR	M	701	831	1	1	1	1	1	1	1	
925	TR	M	901	1031						1	1	
925	TR	M	101	1231								1
926	TR	L	101	1231	1	1	1	1	1	1	1	1
927	TR	L	101	1231	1	1	1	1	1	1	1	1
928	TR	L	101	1231	1	1	1	1	1	1	1	1
929	TR	L	101	1231	1	1	1	1	1	1	1	1
930	TR	L	101	1231	1	1	1	1	1	1	1	1
931	TR	L	101	1231	1	1	1	1	1	1	1	1
932	TR	L	101	1231	1	1	1	1	1	1	1	1
933	TR	L	101	430	1	1	1	1	1	1	1	
933	TR	L	501	630	1	1	1	1	1			
933	TR	L	901	1031	1	1	1	1	1			
933	TR	L	1101	1231	1	1	1	1	1	1	1	
933	TR	M	501	630						1	1	
933	TR	M	701	831	1	1	1	1	1	1	1	
933	TR	M	901	1031						1	1	

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
933	TR	M	101	1231								1
934	TR	L	101	1231	1	1	1	1	1	1	1	1
935	TR	L	101	1231	1	1	1	1	1	1	1	1
937	P	L	101	331	1	1	1	1	1	1	1	
937	P	L	401	1031	1	1	1	1	1			
937	P	L	1101	1231	1	1	1	1	1	1	1	
937	P	M	401	1031						1	1	
937	P	M	101	1231								1
938	P	L	101	331	1	1	1	1	1	1	1	
938	P	L	401	1031	1	1	1	1	1			
938	P	L	1101	1231	1	1	1	1	1	1	1	
938	P	M	401	1031						1	1	
938	P	M	101	1231								1
942	TR	L	101	430	1	1	1	1	1	1	1	
942	TR	L	501	630	1	1	1	1	1			
942	TR	L	901	1031	1	1	1	1	1			
942	TR	L	1101	1231	1	1	1	1	1	1	1	
942	TR	M	501	630						1	1	
942	TR	M	701	831	1	1	1	1	1	1	1	
942	TR	M	901	1031						1	1	
942	TR	M	101	1231								1
946	TR	L	101	1231	1	1	1	1	1	1	1	1
948	TR	L	101	1231	1	1	1	1	1	1	1	1
949	P	L	101	331	1	1	1	1	1	1	1	
949	P	L	401	630	1	1	1	1	1			
949	P	L	901	1031	1	1	1	1	1			
949	P	L	1101	1231	1	1	1	1	1	1	1	
949	P	M	401	630						1	1	
949	P	M	701	831	1	1	1	1	1	1	1	
949	P	M	901	1031						1	1	
949	P	M	101	1231								1
950	P	L	101	331	1	1	1	1	1	1	1	
950	P	L	401	630	1	1	1	1	1			
950	P	L	901	1031	1	1	1	1	1			
950	P	L	1101	1231	1	1	1	1	1	1	1	
950	P	M	401	630						1	1	
950	P	M	701	831	1	1	1	1	1	1	1	
950	P	M	901	1031						1	1	
950	P	M	101	1231								1
951	P	L	101	1231	1	1	1	1	1	1	1	1
953	MU	L	101	430	1	1	1	1	1	1	1	1
953	MU	L	801	1231	1	1	1	1	1	1	1	1
953	MU	M	501	731	1	1	1	1	1	1	1	1
954	MU	L	101	331	1	1	1	1	1	1	1	
954	MU	L	401	630	1	1	1	1	1			
954	MU	L	901	1031	1	1	1	1	1			
954	MU	L	1101	1231	1	1	1	1	1	1	1	
954	MU	M	401	630						1	1	

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
954	MU	M	701	831	1	1	1	1	1	1	1	
954	MU	M	901	1031						1	1	
954	MU	M	101	1231								1
955	MU	L	101	331	1	1	1	1	1	1	1	
955	MU	L	401	531	1	1	1	1	1			
955	MU	L	901	1130	1	1	1	1	1			
955	MU	L	1201	1231	1	1	1	1	1	1	1	
955	MU	M	401	531						1	1	
955	MU	M	601	831	1	1	1	1	1			
955	MU	M	1001	1130						1	1	
955	MU	H	601	930						1	1	
955	MU	H	101	1231								1
957	MU	L	101	331	1	1	1	1	1	1	1	
957	MU	L	401	630	1	1	1	1	1			
957	MU	L	901	1031	1	1	1	1	1			
957	MU	L	1101	1231	1	1	1	1	1	1	1	
957	MU	M	401	630						1	1	
957	MU	M	701	831	1	1	1	1	1	1	1	
957	MU	M	901	1031						1	1	
957	MU	M	101	1231								1
958	TR	L	101	430	1	1	1	1	1	1	1	
958	TR	L	501	630	1	1	1	1	1			
958	TR	L	901	1031	1	1	1	1	1			
958	TR	L	1101	1231	1	1	1	1	1	1	1	
958	TR	M	501	630						1	1	
958	TR	M	701	831	1	1	1	1	1	1	1	
958	TR	M	901	1031						1	1	
958	TR	M	101	1231								1
959	TR	L	101	1231	1	1	1	1	1	1	1	1
961	TR	L	101	1231	1	1	1	1	1	1	1	1
962	TR	L	101	1231	1	1	1	1	1	1	1	1
963	TR	L	101	630	1	1	1	1	1	1	1	
963	TR	L	901	1231	1	1	1	1	1	1	1	
963	TR	M	701	831	1	1	1	1	1	1	1	
963	TR	M	101	1231								1
965	P	L	101	1231	1	1	1	1	1	1	1	1
967	P	L	101	1231	1	1	1	1	1	1	1	1
970	P	L	101	1231	1	1	1	1	1	1	1	1
973	TR	L	101	1231	1	1	1	1	1	1	1	1
975	P	L	101	1231	1	1	1	1	1	1	1	1
981	TR	L	101	1231	1	1	1	1	1	1	1	1
982	TR	L	101	1231	1	1	1	1	1	1	1	1
984	P	L	101	1231	1	1	1	1	1	1	1	1
987	TR	L	101	630	1	1	1	1	1	1	1	1
987	TR	L	901	1231	1	1	1	1	1	1	1	1
987	TR	M	701	831	1	1	1	1	1	1	1	1
988	TR	L	101	430	1	1	1	1	1	1	1	
988	TR	L	501	1031	1	1	1	1	1			

Site Number	Site-type	Use-level	begin	end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Holiday
988	TR	L	1101	1231	1	1	1	1	1	1	1	
988	TR	M	501	1031						1	1	
988	TR	M	101	1231								1
993	TR	L	101	1231	1	1	1	1	1	1	1	1
994	P	L	101	1231	1	1	1	1	1	1	1	1
995	P	L	101	1231	1	1	1	1	1	1	1	1
998	MU	L	101	1231	1	1	1	1	1	1	1	1
999	MU	L	101	331	1	1	1	1	1	1	1	
999	MU	L	401	531	1	1	1	1	1			
999	MU	L	901	1130	1	1	1	1	1			
999	MU	L	1201	1231	1	1	1	1	1	1	1	
999	MU	M	401	531						1	1	
999	MU	M	601	831	1	1	1	1	1			
999	MU	M	1101	1130						1	1	
999	MU	H	601	1031						1	1	
999	MU	H	101	1231								1
1000	MU	L	101	331	1	1	1	1	1	1	1	
1000	MU	L	1101	1130	1	1	1	1	1			
1000	MU	L	1201	1231	1	1	1	1	1	1	1	
1000	MU	M	401	531	1	1	1	1	1	1	1	
1000	MU	M	601	1031	1	1	1	1	1			
1000	MU	M	1101	1130						1	1	
1000	MU	H	601	1031						1	1	
1000	MU	H	101	1231								1
1001	MU	L	101	1231	1	1	1	1	1	1	1	1
1002	MU	L	101	1231	1	1	1	1	1	1	1	1
1003	TR	L	101	1231	1	1	1	1	1	1	1	1
1004	TR	L	101	1231	1	1	1	1	1	1	1	1
1005	P	L	101	1231	1	1	1	1	1	1	1	1
1007	P	L	101	1231	1	1	1	1	1	1	1	1
1009	TR	L	101	1231	1	1	1	1	1	1	1	1
1010	TR	L	101	1231	1	1	1	1	1	1	1	1
1011	TR	L	101	1231	1	1	1	1	1	1	1	1
1015	TR	L	101	531	1	1	1	1	1	1	1	
1015	TR	L	801	1231	1	1	1	1	1	1	1	
1015	TR	L	101	1231								1
1015	TR	M	601	731	1	1	1	1	1	1	1	
1016	P	L	101	1231	1	1	1	1	1	1	1	1
1019	TR	L	101	1231	1	1	1	1	1	1	1	1

List of Acronyms and Abbreviations

AT = Appalachian Trail

ATC = Appalachian Trail Conservancy

ATCH = Appalachian Trail Conservancy Headquarters site-type

CI = Confidence Intervals

CV = Coefficient of Variation

GIS = Geographical Information System

H = High use-level

HF = Harpers Ferry site-type

L = Low use-level

LER = Last-Exiting Recreationist

M = Medium use-level

MU = Multiple Use site-type

NPS =National Park Service

NVUM = National Visitor Use Monitoring

P = Parking site-type

PSU = Primary Sampling Unit

SE = Standard Error

SSU = Secondary Sampling Unit

TWE = Trail-Wide Expansion

USFS = U.S. Forest Service